DESIGN FACTORS AND DATA REQUIREMENTS FOR WATER WITHDRAWAL PRICING AND EFFLUENT CHARGES

Prepared by:

Peat Marwick and Partners
Toronto, Ontario

For:

The Policy and Planning Branch
Ontario Ministry of the Environment

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ONTARIO MINISTRY OF THE ENVIRONMENT

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RÉSUMÉ

Le but de la présente étude est d'examiner les questions relatives au calcul et à la mise en oeuvre, dans le contexte ontarien, d'une redevance pour le prélèvement d'eau brute et le déversement d'eaux usées dans les cours d'eau de surface. Cette étude ne porte pas sur la question de la fixation des tarifs applicables aux ouvrages d'approvisionnement en eau des municipalités et aux ouvrages de traitement des eaux usées.

L'étude en arrive aux conclusions générales suivantes :

- En partant du principe que c'est l'utilisateur qui paie, et ce en fonction du coût de cette utilisation pour la société, les redevances de prélèvement et de pollution sont parfaitement justifiées en Ontario.
- En prévision de l'accroissement de la demande dans l'avenir et de la possibilité d'un plus grand nombre de conflits concernant le prélèvement de l'eau, il peut s'avérer préférable d'introduire dès maintenant le principe d'une redevance.
- Il peut être approprié d'établir un barème uniforme basé sur le revenu pour faire accepter le principe d'une redevance et récupérer les frais entraînés par la gestion de l'eau.
- Dans le cas de l'utilisation de l'eau pour le déversement des déchets, il est clair que l'Ontario en subit les coûts sociaux (dommages) et que ceux-ci iront probablement en augmentant à l'avenir.
- Afin de tirer les recettes prévues des redevances imposées pour le rejet de certains polluants, on pourrait mettre sur pied une redevance de pollution basée sur le revenu.
- Dans le cas des cours d'eau où les dommages environnementaux sont particulièrement graves, et où il faut ramener à des objectifs précis le rejet de certains polluants, on pourrait faire appel à une redevance basée sur les coûts marginaux pour respecter ces objectifs au coût le moins élevé possible pour la société.
- L'établissement d'une redevance de pollution exigerait la mise sur pied d'un système de surveillance fiable, et acceptable aux deux parties.

. Des recherches plus approfondies doivent être entreprises dans les domaines suivants :

- La marge des prix à établir en fonction de la demande pour différentes catégories d'utilisateurs.
- Le coût en capital et les frais d'exploitation des techniques de recirculation favorisant l'économie, ainsi que des techniques de dépollution.

Le 15 décembre 1987

EXECUTIVE SUMMARY

OBJECTIVES

The objectives of this study may be summarized as follows:

- A review and critique of the manner in which other selected resource prices (royalties, etc.) are set in Ontario (timber, minerals, natural gas).
- A review and critique of existing water pricing schemes in Ontario and elsewhere (focusing on resource pricing, rather than end-use pricing), based on clearly-defined principles or criteria.
- A review and critique of existing waste water emission charge schemes in Ontario and elsewhere, based on clearly-defined principles or criteria.
- The specification of possible water pricing designs, in consultation with the Ministry.
- The specification of possible waste water emission charge schemes, in consultation with the Ministry.
- The identification of data required to implement these schemes.
- The determination of administrative and operational tasks associated with selected water pricing and effluent charge schemes for the Ministry, water users and dischargers, and an estimation of their costs.

The activities carried out for this study included a literature review, an interview program, data collection and analysis.

SUMMARY AND CONCLUSIONS

The results of the tasks carried out to meet the study objectives are summarized in Chapter X.

On the basis of the tasks carried out for this study, we make the following overall conclusions:

- There is justification, in terms of the user pay principle and the principle of social opportunity cost pricing, for the pricing of both raw water and effluents in Ontario.

  However, the social opportunity costs associated with current withdrawal uses of raw water in Ontario appear to be relatively low overall. In localized instances only, there are examples of the imposition of social opportunity costs due to water withdrawals. Thus, it is difficult to justify more than very nominal charges for water withdrawals at present.

  The costs associated with raw water withdrawal uses are incurred by society in Ontario primarily in the form of public water management activities.

- It may be desirable to establish the principle of water pricing now, in anticipation of future growth in demand, and a potentially higher number of water withdrawal use conflicts.

- A revenue based water pricing scheme with a uniform charge rate may be appropriate to establish the principle of water pricing, and to recover public water management costs.

- In the case of the use of water for waste disposal, it is clear that social costs (damages) are occurring in Ontario, and that these will probably increase in the future.

- A revenue based effluent charge scheme may be designed to achieve specified target revenues from charges for the emissions of selected pollutants. The revenue targets might include estimated pollution damages, and public water quality management costs. The scheme should result in some abatement by polluters in response to charges.

- In watercourses where environmental damages are particularly severe, and it is desired to reach specified emissions objectives for certain pollutants, a marginal cost based charge scheme could be designed to achieve these objectives at the least cost to society. The charge rate is based on the marginal costs of abatement technology for polluters. Implementation of the scheme would therefore require the initial investment of funds for the development of appropriate abatement cost data for polluters or groups of polluters on the affected watercourses.

- Effluent charge schemes would also require a reliable and mutually acceptable monitoring system. A reasonable approach is to accept loadings data as currently reported by polluters (in the Industrial and Municipal Monitoring

Information Systems) and to implement a systematic audit or verification program.

- In order to facilitate the analysis of the feasibility and potential impacts of water and effluent charge schemes, further research is required in the areas of:
  - the price elasticities of demand for water services for different water user categories (e.g., agricultural use, major industrial groupings and residential use)
  - the capital and operating costs associated with water-saving and recirculating technologies and for pollution abatement technologies.

I - INTRODUCTION

In this Chapter, we outline the background, objectives and scope of this study.

BACKGROUND

There has been an increasing level of awareness and concern regarding the management of water resources in Canada. The concerns relate to both the availability and the quality of fresh water resources. The relative emphasis placed on these two aspects differs from region to region within Canada. For example, availability of water supplies is of great concern in the relatively dry prairie regions of Western Canada, while the quality of available water is often of concern in the moister regions of the East, such as Ontario, where water-using industries tend to locate.

Fresh water, from both surface and groundwaters, constitutes a valuable natural resource, as do, for example, forests, minerals, oil and natural gas. Whereas provincial ownership of most natural resources is set forth constitutionally, the jurisdictional authority over water resources is less clear and is shared with the federal government.[1]

Nevertheless, the provinces do have wide jurisdiction over water. For example, the Ontario Ministry of the Environment administers a wide range of regulatory programs covering both quantity and quality aspects of water management.

In the case of timber, minerals and natural gas, the Province of Ontario levies a variety of taxes and royalties in order to obtain compensation for the beneficial use of these natural resources by industry. In contrast, most users of raw water do not pay for its use as a resource, although they may pay charges related to the costs of delivery. Exceptions to this statement include the generation of hydroelectric power, in which the power utilities pay charges which are related to the volume of water used.

Charges for raw water would tend to create financial incentives for the end-users to use less water and thus to make more efficient use of available supplies.

The discharge of wastewaters into the natural watercourses, for example, from industrial and municipal uses, places a burden on the assimilative capacities of the receiving waters. At present, users usually pay nothing for these services of the natural environment (although some industrial users connected to a municipal sewer system pay "sewer surcharges" for extra-strength wastes). Charges for these water services could provide financial incentives for users to reduce the amount of their discharges.

There is an increasing emphasis on user charges as an economic tool for resource management. With respect to water, for example, the Final Report of the Inquiry on Federal Water Policy by Pearse et al (1985, page 99) has recommended that the federal government should "encourage water conservation and demand management practices by explicitly endorsing the principle that beneficiaries should pay for water and waste water services by means of appropriate prices".

Pearse et al (1985, page 102) also discuss the large amounts of capital needed to rehabilitate and expand aging municipal water supply and wastewater treatment systems in Canada. The report focuses attention on the need for more appropriate pricing policies in order to cover the full costs of these services from users and to encourage more efficient use of existing supplies.

The current study is intended to examine issues of design and implementation, in the Ontario context, associated with the possibility of assessing user charges on both withdrawals of raw water from, and on the discharge of wastewaters into, natural surface watercourses. It does not address the issues and design of pricing policies for municipal water supply and wastewater treatment systems.

OBJECTIVES AND SCOPE

The objectives of this study may be summarized as follows:

- A review and critique of the manner in which other selected resource prices (royalties, etc.) are set in Ontario (timber, minerals, natural gas).
- A review and critique of existing water pricing schemes in Ontario and elsowhere (focusing on resource pricing, rather than end-use pricing), based on clearly-defined principles or criteria.
- A review and critique of existing waste water emission charge schemes in Ontario and elsewhere, based on clearly-defined principles or criteria.
- The specification of possible water pricing designs, in consultation with the Ministry.
- The specification of possible waste water emission charge schemes, in consultation with the Ministry.
- The identification of data required to implement these schemes.

- The determination of administrative and operational tasks associated with selected water pricing and effluent charge schemes for the Ministry, water users and dischargers, and an estimation of their costs.

The activities carried out for this study included a literature review, a personal and telephone interview program, data collection and analysis. Appendix E contains a list of the various individuals contacted for the interview program.

The Terms of Reference for this study identified questions of ownership of surface waters as one of the problems in implementing water pricing or effluent charge schemes. Private ownership and rights, as well as provincial and federal powers regarding water use, must all be considered. The scope of this study does not permit us to explore problems associated with ownership and jurisdictional authority over water. Rather, we will, as required, implicitly assume that the Province has the authority to implement royalties or user charges of this type.

The last objective noted above deals with activities and costs, to all parties, of selected schemes. The level of detail which can be reported is determined by the availability of relevant data.

NOTES FOR CHAPTER I

1. See Pearse et al (1985), the Final Report of the Inquiry on Federal Water Policy. Chapter 6 contains a summary of the various jurisdictional issues surrounding authority over water management in Canada.

II - WATER USE IN ONTARIO

In this Chapter, we provide a classification of the various uses for water, and an overview of the extent of such uses in Ontario, based on available data.

THE HYDROLOGIC CYCLE[1]

Water is constantly changing location or physical state. Water vapour is contained in the free-flowing atmosphere surrounding the earth. Under the proper conditions, it may fall as rain to the ground where it may run off to lakes and rivers, percolate downward to natural underground reservoirs (aquifers), or be absorbed and transpired by plants (as vapour). Surface waters are constantly evaporating to the atmosphere. If water falls as snow, it does not re-enter the hydrologic cycle until it thaws. Thus water forms an indispensible and integral component of the natural environment and is part of the life-support system for both plants and animals, including humans.

THE USES OF WATER

In addition to life-support uses of water, man's uses of both surface and groundwaters cover a wide range, primarily in the liquid state. Probably the most important distinction in classifying water uses is between withdrawal and instream uses of water. Withdrawal generally means removal of water from its natural course. Some water is consumed, but most of the water (except in agriculture) eventually returns to the water course, sometimes in an altered condition. Instream uses involve the use of water in its natural watercourse, for example, for recreational purposes.

EXHIBIT II-1

USES OF WATER

Withdrawal Uses

- Private (rural) residential consumption
- Firefighting
- Municipal (includes some firefighting and industrial uses)
- Agricultural (irrigation)
- Thermoelectric power generation (coolant for fossil fuel and nuclear generation)
- Industrial (process and cooling water).

Instream Uses

- Aquatic systems, wild life, biological and human life support
- Traditional life styles of Native peoples
- Recreation (sport-fishing, boating, cottaging, etc.)
- Non-participatory uses:
    - bequest
    - existence
    - option (potential use).
- Navigation
- Commercial fishing
- Waterborne transportation (e.g., logs)
- Hydroelectric power generation
- Waste assimilation including transport (municipal, industrial, thermoelectric power)
- Flood and drought control.

Exhibit II-1, opposite, provides a classification of the uses of water, by instream or withdrawal uses. The following notes apply to this Exhibit:

- Hydroelectric power generation is usually considered an instream use, although in many instances large works are constructed for flow control and storage or diversion.

- Waste assimilation and transport refer to discharges of effluents, primarily by municipalities and industries. Depending on the quantities and makeup of the waste discharges, and the nature of the receiving waters, the receiving waters may be able to assimilate or neutralize the discharges. We discuss this service provided by water in its natural water course in more detail below.

- The non-participatory instream uses of water include:

    - bequest -- this refers to the desire of some people to provide natural water resources to future unborn generations

    - existence -- this refers to the amenities (e.g., visual) which may be derived from water in its natural state

    - option -- this refers to the desire of some people to reserve the possibility of future instream uses of water (e.g., recreational).

- Flood and drought control may be achieved by the use of dams and reservoirs on some watercourses.

Exhibit II-1 classifies water use, more by the end-user than by the services provided by water to users. The services actually of benefit to users generally depend on specific properties of water. In industrial applications, for example, water may be used as a dilutant, solvent, suspending medium, or coolant. Such services are the sources of value in use for users and result in the demand for raw water.

The two major attributes of water in its natural watercourse are its available flow and its assimilative capacity. Receiving waterbodies have various dilution, dispersion and assimilative capacities with respect to their ability to mitigate or neutralize the effects of discharged pollutants. For example, assimilative capacity may refer to the ability to decompose biodegradable compounds such as those measured by biochemical oxygen demand (BOD). On the other hand, receiving waters may have less ability to assimilate non-biogradable compounds such as heavy metals, persistent organic materials and those which bio-accumulate. In this case, the ability of natural waters to "assimilate" these may only refer to their dilution and dispersion capabilities. The total quantities of these persistent compounds in the environment will increase over time.

In broad terms, water quality refers to measures of the presence of pollutants in waterbodies. For waterbodies used to receive waste discharges, water quality measures may be thought of as indicators of the extent to which the assimilative capacity has been depleted. Decreasing quality can be associated with decreased capacity to assimilate additional polluting materials.

Both withdrawal and instream water uses usually require a combination of available flow and minimum quality with respect to impurities and pollutants. The minimum quality requirement varies widely from use to use. This fact gives rise to conflicts in use on a given watercourse. For example, increasing pollution can lower water quality to a point below that required for life support for fish populations. We might also say that the assimilative capacity of the waters for additional pollutants is nil.

We discuss water use conflicts in greater detail below.

WATER USE IN ONTARIO

Sources Of Data

The following are brief descriptions of data sources available for both water withdrawals and wastewater discharges for Ontario.

- Industrial Monitoring Information System (IMIS). This data base maintained by MOE includes entries for approximately 150 direct dischargers into Ontario surface waters (industrial and thermoelectric generation plants). These are polluters whose effluent quality is of concern to Ministry field staff.[2] (It should be noted that there are approximately 11,000 other polluting firms who discharge indirectly into municipal sewer systems.) For each industrial point-source in IMIS, data recorded included:
    - company name and industrial activity
    - receiving waterbody
    - average annual effluent volume (cubic meters/day)
    - pollutants emitted and average annual loading (kg/day)

  - existing guideline requirements, control orders, status of compliance, comments.

- Utility Monitoring Information System (UMIS). This system is maintained by MOE and contains data on all public water treatment and sewage treatment plants in Ontario (about 400 in total). The data entries include:[3]

  - for water treatment plants: municipality, type of treatment, plant capacity (thousand cubic meters/day), average daily treated flow volume

  - for waste treatment plants: municipality, type of treatment, average day treated flow volume, average day concentration and loadings for both influent and effluents for the pollutants BOD, TSS and Total Phosphorus.

- Water Taking Information System (WTIS). The Ministry of the Environment administers a Permit To Take Water Program, under which most takings in excess of 10,000 gallons (50,000 litres) per day from both surface and ground waters require authorization by means of a Permit to Take Water. Excluded are the taking of water by an individual for ordinary household purposes, livestock watering, and firefighting. Applications for permits are reviewed in the light of available supplies and the impacts of the proposed taking on existing uses. The resolution of interference problems is dealt with through administrative discretion. A description of the goals, policies, objectives and implementation procedures for water management in Ontario can be found in Ministry of the Environment

(1984). WTIS is a computerized data base incorporating certain data for each permittee. The data base was updated until about 1984. However, data on new permits or updates to existing permits are available only in manual files[4]. The data items recorded in WTIS include:

- name, location
- water use, source type and name, ground or surface water
- authorized rate of withdrawal (actual withdrawals are not recorded or measured).

o National Industrial Water Use Survey. The Federal Government carries out an industrial water use survey every five years, corresponding to census years. The last one was carried out for 1981.[5] A detailed water use survey was sent to the manufacturing firms in the top ten water using industries included in Statistics Canada's mailing list for the "long form" census of manufacturing. This procedure is expected to capture 90% to 95% of manufacturing water use. Response rates are quite high.[6] The data gathered in this survey include:

- manufacturing sector, location
- water intake volume, source type, self-or publicly supplied
- gross water use (including volumes recirculated)

  - volumes of water discharged and discharge location

  - costs of intake, treatment, recirculation and discharge (usually excluding capital costs).

These are the only centralized water withdrawal data available for Ontario, except for municipal water treated (UMIS) and water withdrawn for thermoelectric coolant purposes. (Municipal water treatment facilities may have records for individual users).

Water Withdrawals In Ontario

Exhibit II-2, opposite, provides a broad summary of water withdrawals from Ontario water sources. These data are drawn from a research paper for the Inquiry on Federal Water Policy by Tate (1985, Appendix A, pages A-165 to A-167). The following notes refer to this Exhibit:

- The data in the Exhibit are actual values in the case of municipal and thermoelectric withdrawals. For the industrial uses, the data are based on the Industrial Water Use Survey carried out by Environment Canada in 1981. Agricultural use is estimated.[7] UMIS is the source of the federal data on municipal water usage.[8]

- About 70% of withdrawals are taken by thermoelectric generating stations (natural gas, oil, coal, uranium-fired) for coolant purposes. These waters are returned intact, although at a higher temperature than the receiving waters.

EXHIBIT II-2

WATER WITHDRAWAL IN ONTARIO, 1981[1]
(Millions of Cubic Metres - MCM)

	Withdrawal		Gross Use[2]		Consumption[3]	
	MCM	% of Total	MCM	Ratio to Withdrawal	MCM	% of Withdrawal
Agriculture	148	1	148	1.0	123	83
Minerals	124	1	288	2.3	12	10
Manufacturing	4,577	22	8,536	1.9	200	4
Thermoelectric Power Generation (Coolant)	14,930	70	14,930	1.0	36	neglig.
Municipal	1,450	7	1,450	1.0	218	15
TOTALS	21,230	100	25,352	1.1	589	3

NOTES:

1. Source: Donald M. Tate, "Alternative Futures of Canadian Water Use, 1981-2001", Inland Waters Directorate, Environment Canada, May 1985. Does not include rural residential direct withdrawals, which amount to less than 1% of the above total.

2. Gross Use is the quantity of water required (in the absence of a recirculation system). The ratio of gross use to withdrawal refers to the extent to which water is re-circulated before discharge. A value of 1.0 indicates "once through", while values greater than 1.0 indicate the extent of re-circulation.

3. Consumption is the difference between intake (withdrawal) and discharge. This water may be incorporated in end products or, in some processes may evaporate. In the case of agricultural irrigation, both evaporation and percolation to groundwaters may occur. In any case, consumption generally refers to waters which do not reach the water course from which they were withdrawn.

- Waters withdrawn in the minerals processing and manufacturing uses are recycled about twice on average. (According to Postel (1985), based on census data, the overall average recycling rate in the United States for industrial uses was 3.42 in 1978, and forecasted in 1981 to be more than double this by 1985.)

- Although agricultural (irrigation) uses, mostly from surface waters, account for less than 1% of total withdrawals, a large proportion of this water (83%) does not return to the water course. It may evaporate or percolate to underground storage waters. In smaller waterbodies, and in dry years, available flows may sometimes be severely reduced by irrigation demands.

- Although groundwater withdrawals are not broken out in this Exhibit, Pearse et al (1985, pg. 41) indicates that, for Ontario, about 398 MCM, or about two percent of total withdrawals, are from groundwaters. Almost half of this is for municipal uses, while about another one-third is split between rural residential and farm (livestock) uses. The rest is for mining and irrigation uses.

As can be seen in Exhibit II-2, a certain proportion of withdrawals is consumed. That is, it does not reach, or is not discharged by the user into the original waterbody from which withdrawals were made. Consumed water may be incorporated into other final products (food industries) or it may evaporate (irrigation and some industrial uses), percolate into untapped groundwaters, or be lost through leaks in distribution systems (municipal). The rate of consumption is very high for irrigation, although the overall amount of water involved is relatively low in Ontario.

The major concern with excessive withdrawals is that residual flows may be less than the minimum flow requirement for a given river or other waterbody. Determination of precise minimum requirements is difficult. Conceptually, however, such a parameter should be made available in order to assist in protecting uses which depend on flow, such as habitat for fish and aquatic systems, recreational uses, other withdrawal uses, etc.

The extent to which available flows are decreased by withdrawals in a given watercourse depends on:

- the number of competing withdrawals in close proximity
- the locations of their discharge outlets, or the locations where runoff waters reach the watercourse
- the extent of actual consumption.

Excessive withdrawals may also be of concern in the case of groundwater. In general, a groundwater source has a safe yield rate of withdrawal which is based on its rate of recharge. Exceeding the safe yield on a continued basis would tend to deplete that resource in the long run.

For Ontario, the percentage of available annual flows (axcluding groundwater supplies) represented by the withdrawals for 1981 shown in Exhibit II-2 is estimated at about 8.7%, based on river basin regional data presented in Pearse et al (1985, page 46). Except for irrigation uses, most of this water returns to the original waterbody. This can be interpreted as a favourable balance of demand versus supply. However, these aggregate figures can mask wide variations at a more disaggregated level. For example, the comparable figure for the Great Lakes basin area is 27.5%, of which about 70% is coolant water drawn from the Great Lakes for thermoelectric power generation. However, due to the size of the lakes, their levels are not significantly impacted.

EXHIBIT II-3

INDUSTRIAL WATER WITHDRAWALS IN ONTARIO, 1981[1]
BY PUBLIC AND SELF-SUPPLIED
BY SURFACE AND GROUNDWATER
(Million Cubic Meters MCM)

		Total Withdrawal	Source		
				Self-Supplied	
Minerals Extraction[3]			Public	Surface	Ground/Other
05[2]	Metal Mines	108	10	90	8
06	Mineral Fuels	1	-	1	-
07	Non-Metal Mines	16	-	12	4
	Subtotals	124	10	102	12
Manufacturing[4]					
10	Food and Beverages	127	61	56	11
16	Rubber and Plastics	29	15	8	6
18	Textiles	84	8	76	-
25	Wood Industries	4	-	3	-
27	Paper and Allied Products[5]	620	25	594	-
29	Primary Metals[5]	1,160	57	1,101	2
30	Metal Fabricating	17	13	3	1
32	Transportation Equipment	90	34	56	-
35	Non-Metallic Minerals	52	8	35	8
36	Petroleum Industries[5]	330	4	325	1
37	Chemical and Chemical Products[5]	1,901	41	1,825	8
	Other Manufacturing[6]	163	10	153	-
	Subtotals	4,577	276	4,264	37
Thermoelectric Power Generation[7]					
	Industrial Facilities	672	6	666	-
	Utilities	14,258	-	14,258	-
	Subtotals	14,930	6	14,924	-

Notes:

1. Some totals may not balance due to rounding.
2. Two digit major SIC code.
3. Source: Tate and Scharf (1985b, Table 2.11).
4. Source: Tate and Scharf (1985a, Table 1.11).
5. These four industry groupings account for 88% of total manufacturing water intake.
6. Personal communication, Mr. D. Tate, Environment Canada.
7. Source: Tate and Scharf (1985b, Table 3.09).

Exhibit II-3, opposite, provides more details regarding the water withdrawals in Ontario. The major categories of manufacturing, mining and thermoelectric power generation are further broken down by 2 digit Standard Industrial Classification code (SIC). In addition, withdrawals are split between public and self-supplied sources (including surface and groundwater sources). Public sources refer to supplies purchased from municipalities, while self-supplied sources refer to those accessed directly with user-owned equipment.

It can be seen that the four major water using industries (88% of manufacturing uses) are, in decreasing order of withdrawal:

- chemical and chemical products industries
- primary metal industries
- paper and allied products industries
- petroleum industries.

It can also be seen that while publicly supplied water accounts for about 6% of total intake overall, some industries use a high proportion of public supplies:

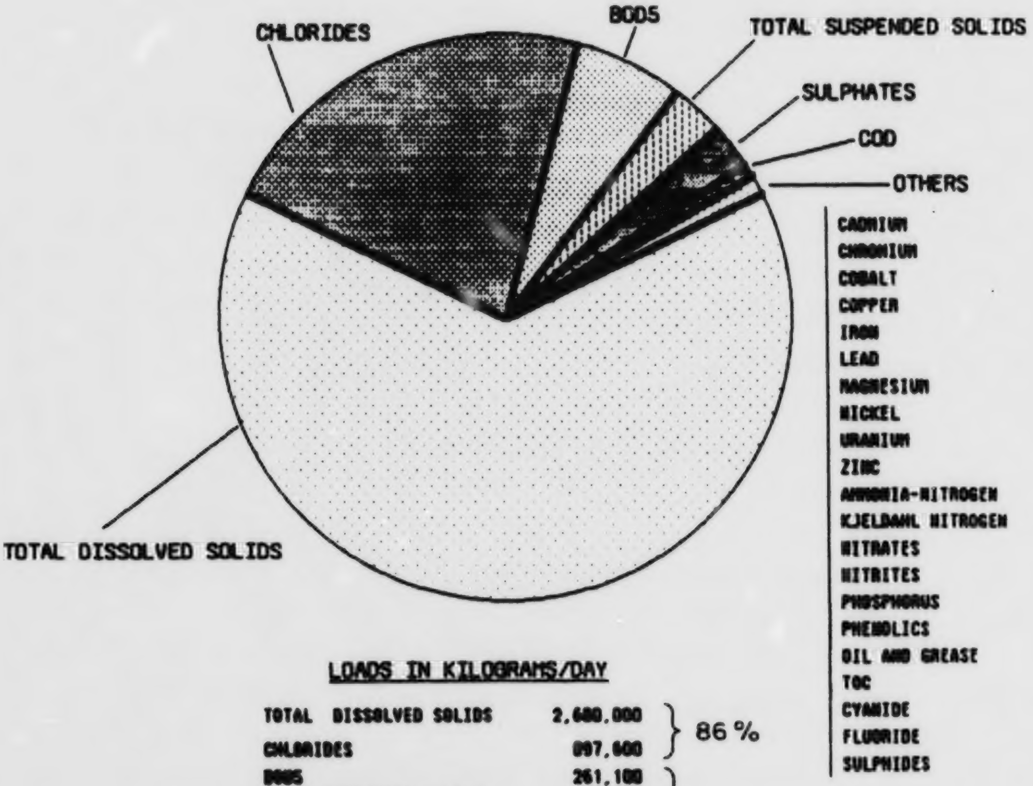
- food and beverage industries
- rubber and plastics industries
- transportation equipment industries.

Waste Water Discharges In Ontario

Many industrial, manufacturing, mining and thermoelectric power generation facilities use Ontario's surface waters for waste assimilation and transport. A wide variety of pollutants is contained in their discharged waste waters.

EXHIBIT II-4

ONTARIO
POLLUTANT DISCHARGES
(GREAT LAKES BASIN)
1984



LOADS IN KILOGRAMS/DAY

TOTAL DISSOLVED SOLIDS	2,680,000	86 %
CHLORIDES	897,600	
BOD5	261,100	14 %
TOTAL SUSPENDED SOLIDS	127,300	
SULPHATES	93,300	
CHEMICAL OXYGEN DEMAND (COD)	44,300	
OTHERS	43,340	
TOTALS	4,146,939	100 %

THE TOTAL DISSOLVED SOLIDS TEST MEASURES THOSE COMPOUNDS THAT ARE DISSOLVED
IN WATER; DEPENDING UNPON THE CONCENTRATION THESE COMPOUNDS MAY BE USEFUL OR HARMFUL.
IT IS USED AS AN INDICATOR TEST.
FRESH WATER CONTAINS CHLORIDES AT A VERY LOW CONCENTRATION AND THESE COMPOUNDS ARE DETECTED BY THE
TOTAL DISSOLVED SOLIDS TEST. THE LABORATORY ANALYSIS FOR CHLORIDE ACTUALLY MEASURE CHLORIDES, BROMIDES,
IODIDES AND CYANIDE.

SOURCE : FIGURE 1, PAGE 62, MINISTRY OF THE ENVIRONMENT (1986)

Classification Of Waterborne Pollutants

Appendix D contains a classification and description of waterborne pollutants, based on Ontario Ministry of the Environment (1986, pages 5-11) and Pearse et al (1985, Chapter 5).

Pollutant Discharges Into Great Lakes Basin, 1984

The Ministry of the Environment (1986) has produced an inventory of direct industrial discharges into the Great Lakes basin for 1984. It is noted that the inventory does not include the vast majority of the about 11,000 industrial plants in Ontario which discharge into a municipal sewer system. The inventory was developed from IMIS and covers over 100 large industrial point source locations. These sources were chosen on the basis of criteria relating to:

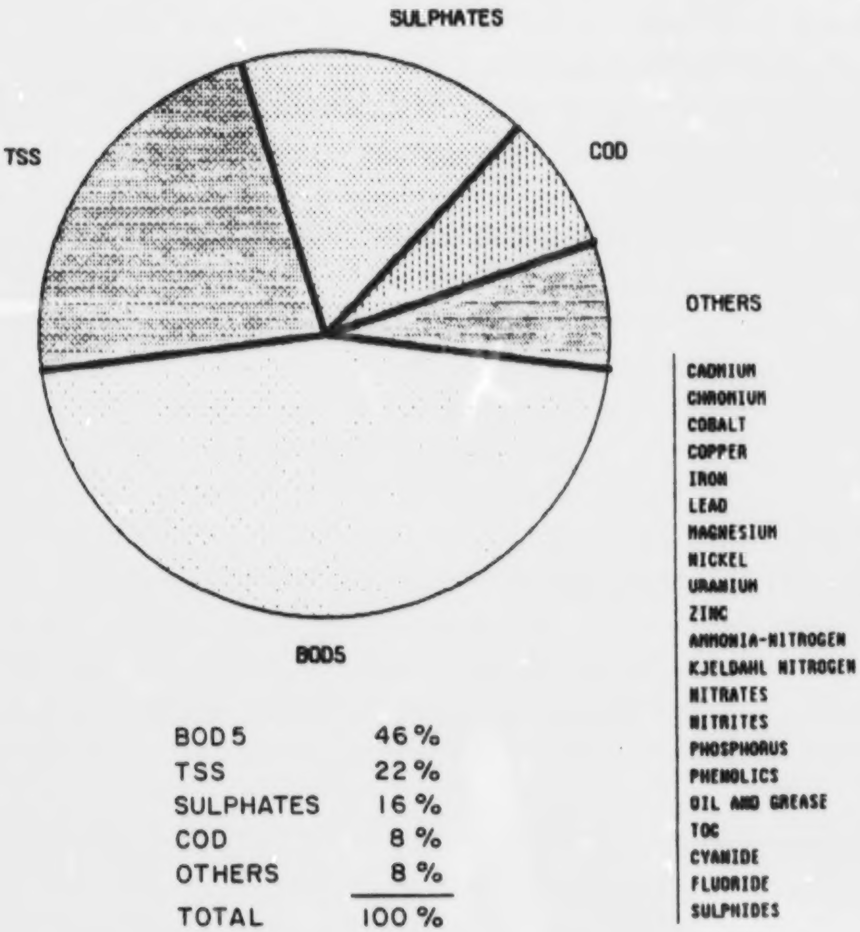
- Emission into an "Area of Concern" in the Great Lakes system, as defined by the International Joint Commission.
- Emission of a persistent toxic.
- Emission of certain pollutants (e.g., phosphorus, TSS, BOD) above certain daily threshold rates in kg./day.

Figures 1 and 2 of the Ministry Report provide summary charts of total daily loadings of all pollutants listed in Appendix D. Exhibit II-4, opposite, is a facsimile of Figure 1 of the Report. It can be seen that TDS and chlorides account for about 86% of all loadings.

However, due to the fact that some test measurements double count chlorides, and the fact that chlorides are found in natural waters, it is stated that by excluding TDS and chloride loadings, the significance of

EXHIBIT II-5

ONTARIO
POLLUTANT DISCHARGES
EXCLUDING TDS AND CHLORIDES
(GREAT LAKES BASIN)
1984



BOD 5	46 %
TSS	22 %
SULPHATES	16 %
COD	8 %
OTHERS	8 %
TOTAL	100 %

TOTAL - 569, 339 KILOGRAMS PER DAY

SOURCE : FIGURE 2, PAGE 61, MINISTRY OF THE ENVIRONMENT (1986) various pollutants in Ontario can better be presented.[9] Exhibit II-5, opposite, is a facsimile of Figure 2 of the Report which excludes TDS and chlorides. It can be seen that, among the remaining pollutants, BOD and TSS are the major pollutants in terms of loadings (kg./day), accounting for about 46% and 22%, respectively.

Criteria For Choice Of Pollutants For An Effluent Charge Scheme

There is a large number of waterborne pollutants which are discharged to the environment in Ontario. The following criteria would be important in determining which pollutants could be the subject of an effluent charge scheme:

- Not directly toxic or lethal to humans under current levels of emissions. Lethal or toxic pollutants still require other management approaches.

- Emission levels capable of being quantitifed in standard units such as kilograms or tonnes.

- The existence of a reasonably accurate and widely accepted measurement or monitoring procedure.

- The ability to determine the sources of the pollutants. This may imply the need for inventories or data bases, such as IMIS and UMIS.

These criteria can be satisfied by such pollutants as BOD and TSS.

CONFLICTS IN CURRENT USES

The use profile for each waterbody may consist of a combination of withdrawal and instream uses. Some uses may be competitive, while others are complementary.

In the competitive case, the use of water by one user may reduce the amount available for another user. On the other hand, complementary uses may not affect each other. (For example boating, and withdrawal of municipal waters from Lake Ontario don't compete with each other.)

It is possible to broaden the definition of consumption of available flows in the case of some competitive uses. For example, an instream use which requires minimum flow rates (say, navigation or ecosystems) can be considered to have "consumed" the minimum flow without withdrawing it, since only a portion of available flows would be available for other competing consumptive uses, say, irrigation.

In general terms, conflicts in the use of a given waterbody may occur when one or more of the uses results in changes to the available levels of either the flow, or the quality of the water.

Perhaps the most important conflicts involve the the use of waters for waste disposal and the impacts of the resulting decreased water quality on other uses. We have noted that most instream and withdrawal uses require available flows at a minimum quality. Changes in water quality (including excess heat) can affect, among others:

- Instream uses such as:
    - fish, wildlife and other ecosystems:
    - recreational uses
    - non-participatory uses.

- Withdrawal uses such as municipal and industrial water needs and irrigation for agriculture.

Decreases in quality can result from a number of uses, including industrial and municipal discharges, agricultural run-off (pesticides and nutrients), and thermoelectric power generation (excess heat in discharge waters). The effects of decreased quality imposed on other users are costs to society of the production processes giving rise to the pollution discharges. The term externality is generally used to denote such costs, which are not usually borne by the polluter.

Changes in available flow characteristics of a given waterbody due to a certain use, or uses, can have significant impacts on:

- Instream uses, such as:
  - fish and wildlife habits
  - navigation and hydroelectric power generation
  - recreational activities.
- Other withdrawal uses.

Decreases in available flow may be quite localized in nature, and their importance may be seasonal. For example, since most waters, except in agriculture, return to the watercourse, conflicts can arise if users are attempting to withdraw water from approximately the same place in, for example, a stream or river. The withdrawals could reduce flows at this location or downstream below minimum stream flow requirements, depending on where discharges occur or unconsumed waters reappear. The impacts of these withdrawals may be more accentuated in the dry periods of the year. Irrigation withdrawals, which are mostly consumed, may in some cases deplete the available flow of a river, even if they are spaced out along the water course. Though irrigation uses are relatively small in Ontario, they have occasionally resulted in the reduction of available flow below minimum stream requirements.[10] These instances usually relate to smaller rivers in dry years.

Another example involving limited available flows has been identified in the Hemlo area.[11] Mining operations require large quantities of water, which are being withdrawn from a river. Wastewaters undergo lagoon treatment and subsequent discharge to a different watercourse. This has the effect of significantly depleting available flows in the source river. The solutions to this conflict have involved an increased level of investment in recirculating equipment.

It would appear, from available data and conversation with Provincial authorities, that conflicts between withdrawal uses have not been a major problem in Ontario, although some conflicts have arisen, of the types noted above. As withdrawal uses increase in the future, there may be a higher frequency of conflicts. In addition, potential demand for inter-basin transfers could significantly affect existing uses.

Withdrawal uses may also impact on the assimilative capacity of a given waterbody at a given location. By reducing the available flow characteristics, the assimilative capacity for waste discharges may be reduced simply by there being less dissolved oxygen in total for biochemical decomposition, and less water dilution. Conversely, as noted above, depleting the assimilative capacity of a waterbody may, in some cases, reduce the available flow of water for another withdrawal use, if a given quality is required.

Other conflicts in water use in Ontario include the following:

- Public water supplies are increasingly impacted by pollutants.

- Commercial and recreational fishing and non-participatory uses have been threatened by pollutants, acid depositions and over-enrichment by nutrients.

- Traditional life styles of some Native peoples have been affected by flooding from hydroelectric power developments and contamination of fish from industrial pollutants.

- Navigation and power generation interests desire higher water levels in the Great Lakes, while shore property owners prefer lower levels to protect their investment.

- The reduction of groundwater supplies has been of concern in recent years in cases where withdrawals may, in the long run, be exceeding the rate of recharge of the aquifers; this has been of concern in South-central Ontario (Kitchener-Waterloo) where ground waters are predominantly used for municipal water supply.

CONFLICTS BETWEEN PRESENT AND FUTURE USERS

Conflicts between present users and future users may exist depending on the extent to which available flows or assimilative capacities of receiving waters are being depleted. For example, excessive withdrawals at the present time from groundwater sources can result in significant problems or additional costs for future users. In the case of water quality, excessive emission of some persistent pollutants may impose health problems or significant cleanup/treatment costs on future users.

The design of appropriate water quantity and quality management policies includes consideration of future users.

SUMMARY

Although there have been localized instances of reduced streamflow levels due to competing withdrawal uses, it would appear that, on the whole, withdrawal use conflicts have not been a major problem in Ontario in the past, especially on the Great Lakes.

Of much greater concern are decreases in water quality in some drainage basin areas both in rivers and the Great Lakes. These changes affect other uses, both instream and withdrawal. Some changes, involving persistent toxics, are very difficult or costly to reverse.

NOTES FOR CHAPTER II

1. A detailed discussion of the hydrologic cycle can be found in Hirschleifer et al (1970), Chapter II.

2. Personal communication, Mr. W. Suboch, Ontario Ministry of the Environment.

3. Sample outputs provided by Ms. E. Dolinar, Ontario Ministry of the Environment.

4. Personal communication, Mr. D. Vallery, Ontario Ministry of the Environment.

5. Tate and Scharf (1985c) provide a description of the survey.

6. Personal communication, Mr. D. Tate, Environment Canada.

7. Id. The agricultural usage is estimated from International Joint Commission data for Great Lakes irrigation diversions for 1978.

8. Personal communication, Mr. D. Tate, Environment Canada.

9. Ontario Ministry of the Environment (1986, pages 10 and 11).

10. Personal communication, Mr. P. Dennis, Ministry of the Environment.

11. Personal communication, Mr. J. de Bakker, Ministry of the Environment, Northwest Region.

III - ECONOMIC PRINCIPLES

INTRODUCTION

The present study is focused on issues of design and implementation of pricing schemes for raw water, and for discharges of waste water effluent into surface receiving waters. At present in Ontario, users usually pay nothing for these uses of the water resources or natural environment.

This study also provides descriptions and critiques of pricing mechanisms (royalties and taxation) currently in use in Ontario with respect to other selected natural resources including timber, minerals, and natural gas. These examples provide illustrations of various pricing mechanisms and provide a context for the consideration of approaches to the pricing of water resources.

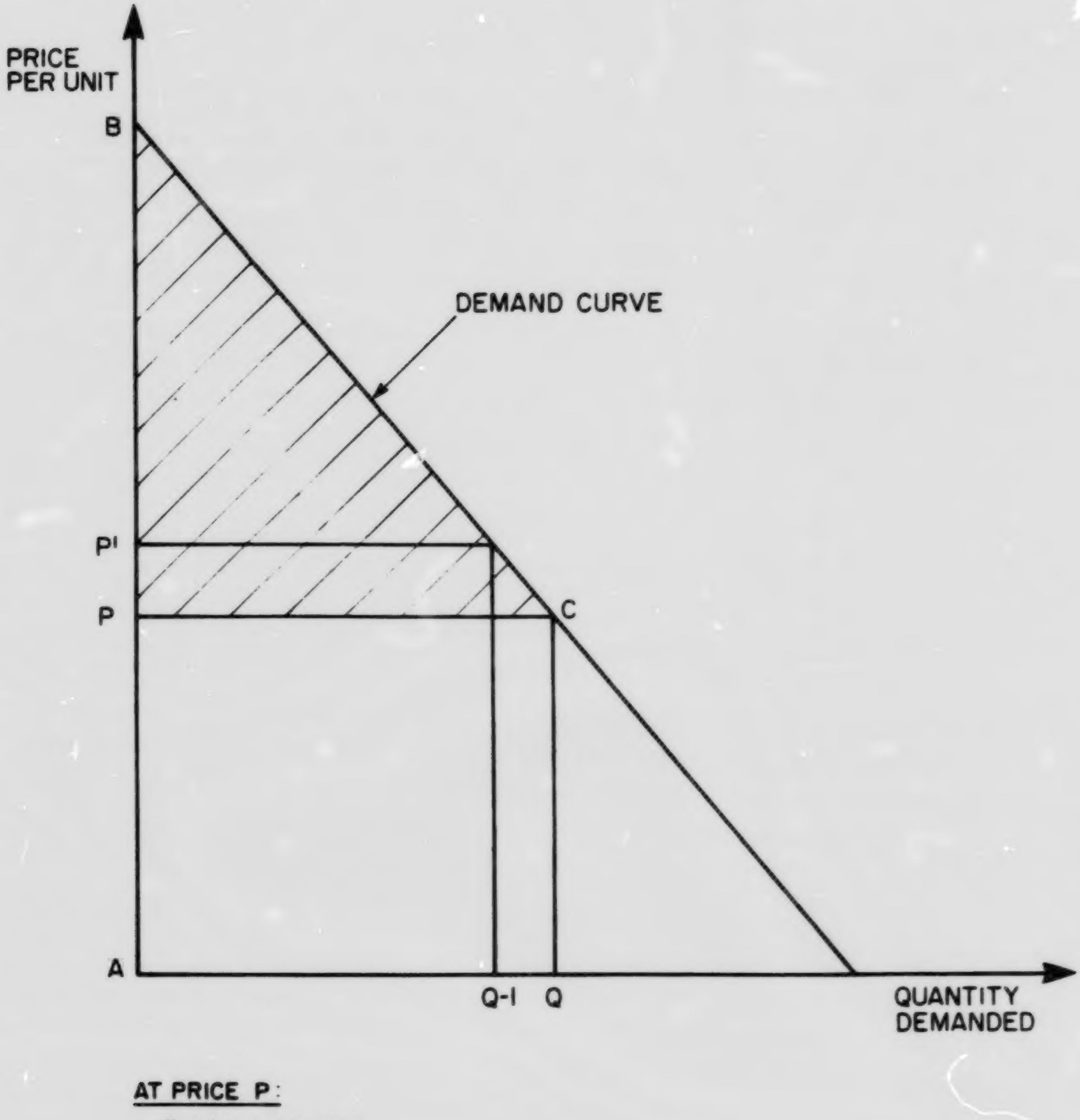
In order to facilitate subsequent discussion of existing resource pricing mechanisms and of the design of water and effluent charge schemes, this chapter will provide an account of the relevant economic principles. Definitions and discussion of terms and of economic principles used throughout the report are included. The following discussion emphasizes broad economic principles rather than providing detailed assumptions and qualifications which would be necessary for a complete understanding.

CONCEPTS OF VALUE[1]

Objects or commodities have value to a user or consumer because they contribute to the consumer's satisfaction, or "utility". This satisfaction is sometimes known as the "value in use". The willingness to pay for a commodity is the basis for a monetary measure of its value in use. The value in exchange for the commodity is the price or quantity of money it will exchange for. The value in exchange results from the operation of a

EXHIBIT III - 1

DEMAND CURVE ILLUSTRATION



AT PRICE P:

- **Total Value in Use or (Total Willingness to Pay) = BAQC**
- **Net Willingness to Pay = BAQC – PAQC = BPC**

market where individuals' willingness to pay and individuals' willingness to accept compensation for giving up the commodity equilibrate to a market price. The monetary measure of the value of a given commodity is, therefore, based on the willingness to pay and to accept payment of individuals making voluntary choices.

Demand Curve and Value

A demand curve for a given commodity is primarily a schedule which shows the relationship between various levels of the willingness to pay (i.e., the price) per unit of the commodity, and the corresponding quantities of the commodity desired at that price. A demand curve can in principle be developed for both individuals and for the total market (an aggregation of individuals) for the commodity.

For most goods, the demand curve, if plotted will "slope downward to the right", such as the straight-line demand curve pictured in Exhibit III-1, opposite. In general, demand curves are in fact curved and may be relatively flat or relatively steep, reflecting demand characteristics relevant to the specific commodity. The downward sloping shape indicates that as the price per unit increases, the quantity demanded decreases.

The demand curve for a given commodity can also be described in terms of value in use. For each price per unit P, a quantity Q will be demanded. The price P may also be interpreted as the marginal price or the value in exchange of the last unit purchased. In this sense, the demand curve may be considered as a schedule of marginal values in use for each amount demanded. A demand curve sloping downward to the right indicates that the marginal values for additional units of a commodity are decreasing. (Note in Exhibit III-1 that the consumer would be willing to pay a lower price per unit for Q units than for a quantity of Q-1 units.)

We can now discuss the relationship between total value in use and total value in exchange. Refer again to Exhibit III-1. If Q units were purchased at a price of P per unit, the total value in exchange would be PQ dollars. However, the total value in use is determined by summing the marginal values in use for each additional unit purchased, starting at zero units and proceding to Q units. The total value in use is then the area under the demand curve defined by the shape ABCQ. This may also be called the total willingness to pay for Q units. The shaded area defined by the triangle BPC is called the net willingness to pay or consumers' surplus and is equal to the total willingness to pay ABCQ, less the total value in exchange, PQ dollars, represented by the rectangle APCQ.[2] The measurement of value in terms of willingness to pay, with reference to demand curves, is consistent with the concept of benefit as used in benefit-cost analysis.[3]

Price Elasticity Of Demand

One of the most important attributes of the demand curve for a commodity is its price elasticity of demand, which reflects the relationship between changes in price per unit and changes in the quantities demanded. The price elasticity of demand, for a given level of demand, is the percentage change in the quantity demanded which would result from a 1 percentage point increase in price. For demand curves which slope downward to the right, the price elasticity is negative (since quantities decrease as price increases).

In response to price increases, the total exchange value (or revenue to producers of a good, say) will increase or decrease, depending on the price elasticity.[4]

- For a price elasticity from 0 to -1 total exchange value increases, and demand is termed inelastic.

- For a price elasticity of -1, total exchange value is unchanged, and demand is termed unitary.
- For a price elasticity of less than -1, total exchange value decreases, and elasticity is termed elastic.

Derived Demand

Manufacturers require inputs of the factors of production, such as labour or raw materials, in order to produce finished outputs for consumers. The demand for a factor of production is thus derived from consumers' demand for the final product.

The elasticity of demand for the factor inputs depends on the elasticity of demand for the final product, the proportion of total costs represented by the factor, and the extent of possible substitution with other factors.[5]

The concept of derived demand is important when considering the various uses and values of raw water. In most cases, raw water is an input to final product. For example, water is commonly an input into industrial processes, and can also be considered an input into the "production" by municipalities of treated and delivered water to residential users.

ALLOCATION OF RESOURCES: EQUIMARGINAL VALUE IN USE

We use the concepts of marginal value in use to discuss the principles of allocation of resources so that the benefits to society are maximized. Hirschleifer et al (1960, Chapter II) discusses these concepts in terms of the allocation of water. We will pursue this approach in order to illuminate the relevant economic principles. However, it should be noted that the examples focus primarily on the allocation and pricing, not of raw water, but of treated and delivered water for customers of public supply systems.

They discuss, first, the allocation of a given costless supply of water to competing users. They conclude that an "efficient" allocation of the water would be one in which all users derived equal value in use (as we have used the term above) from the last (marginal) unit withdrawn. This is the principle of equimarginal value in use. This is an efficient allocation, since no user could obtain further benefits (i.e., value) by buying or selling water in a trade with another user. In this sense, total benefits are maximized. We will return to the concept of efficiency below.

Hirschleifer et al go on to point out that the conditions of equimarginal values in use and efficiency of allocation can be achieved with a pricing scheme in which all users pay the same price. In this case, each user will buy just that amount of water for which the marginal value in use of the last unit purchased will equal the price.

MARGINAL COST PRICING AND ALLOCATIVE EFFICIENCY

Hirschleifer et al continue with the example of the pricing of water which is not costless. We now assume that there are costs associated with developing the supply of water for its users. These include large capital inputs, and operating and maintenance costs for the withdrawal, storage, treatment and distribution of public water supplies. In this case, the correct price to charge is the long run marginal cost incurred in the supply of the next additional unit of water. This will result in an efficient allocation, not only of water, but of society's other resources (labour and capital) which are required to develop the water supplies.

More generally, the term allocative efficiency is used to describe a measure of the extent to which the net benefits to society have been maximized by the use of its resources as inputs to the production and consumption of goods and services. The resource inputs include labour, capital and natural and environmental resources. The allocation of society's scarce resources will result in the maximum benefits to society when prices of goods are equal to marginal costs.[6]

In addition, when all prices are equal to marginal costs, there is no possible adjustment to the use of productive resources without making someone worse off. This is known as a Pareto-optimal allocation of resources.[7]

In evaluating the economic impacts of proposed policies, various aspects of allocative efficiency may be used as criteria, depending on the availability of data:

- Maximization of net benefits:
  - maximizing net benefits to society
  - maximizing profits of private firms.

- Minimization of total costs (cost effectiveness)
  - for society
  - for private firms.

The next section deals more specifically with the definition of costs, particularly in the areas of environmental and natural resource policy considerations.

SOCIAL AND PRIVATE COSTS

In this section, we briefly define various terms related to social and private costs. The terms are used in subsequent discussions on water pricing and effluent charge schemes.

In the development of programs or projects in the resources or environmental areas, including the use of water, the concepts of private and public costs and benefits are particularly important. The following definitions are taken from Donnan (1986, page 9):

- **Private Costs and Benefits** are incurred or enjoyed by the proponent or agency which initiates the project. Private benefits include increased revenues, cost savings or increased profits that result from the project or investment.

- **Public Costs and Benefits** are adverse or beneficial consequences which are imposed on individuals or firms not connected with the project proponent. Public costs are the environmental damages caused by pollution or development activity. Public benefits are biophysical damages that are avoided, reduced or eliminated as a result of a project or a program. Public benefits also include the tangible and intangible beneficial consequences that result from environmental improvement.

The term negative externality has often been used to denote public or social costs as defined above.[8] Negative externalities are usually unintended consequences which affect third parties who are neither the proponents nor users of the outputs of the particular project or program. Externalities may often be considered as inputs to a productive process. For example, environmental degradation often results from the mining of natural resources, and from many manufacturing industries. In most cases, however, these inputs are free. That is, they are not priced in the market place. The fact that these factor costs are not incurred by the producer indicates an inefficient allocation of society's resources.

Opportunity cost is an important concept which may apply to both social or private costs. It generally refers to the value of foregone opportunities associated with choosing one activity over another. For example, the opportunity cost related to a particular investment is the potential return which might be earned in another investment. In the use of natural resources, the opportunity cost includes the impacts or consequences of current use for future supplies.

In the application of the marginal cost pricing principle stated above, for the pricing of natural resources, we must include all relevant costs: private and social costs and opportunity costs.

In fact, OECD (1985, page 10) uses the term "Opportunity Cost" to refer to all costs the associated with the extraction or use of a natural resource. The following list of components of opportunity cost is based on the OECD definition:

- Marginal costs of goods and services require for the provision of the resource.
- Resource depletion costs, i.e., impacts on future use, or on other competing uses.
- Damages, i.e., to the environment.

These categories cover the range of private and social costs. We will use the term social opportunity cost to refer to the total of all (marginal) costs in the application of the marginal cost pricing principle.

NATURAL RESOURCE PRICING AND TAXATION

The Ontario Government uses a variety of approaches in collecting revenues from users of various natural resources. These revenues may be in the form of royalties due for the extraction of each additional unit, or may be in the form of a profits tax on the extraction operation. In the broadest sense, these approaches can be considered a pricing of natural resources by the Crown. The revenues represent user charges for the beneficial use of publicly-owned resources.

In consideration of the principles discussed above, the social opportunity costs associated with resource extraction can include:

- Environmental damages and human impacts resulting from extraction processes.
- Reduction of utilization by competing users. For example, recreational possibilities may be reduced by logging in some areas.
- Impacts of current use on the supply for future users.

Appropriate pricing of natural resources by the Crown would imply recognition of these social costs.

Objectives Of Natural Resource Pricing And Taxation

Given that natural resources are vested in the Crown[9], the overall objective of natural resource pricing and taxation policies generally relates to encouragement of the development and use of natural resources for the maximum long run socio-economic benefits to the people of the province.[10] This overall objective may be broken down into various sub-objectives including:

- Encouragement of employment and regional economic development resulting from resource exploitation.

- Generation of optimum revenues to the Crown from the current and future exploitation of natural resources

- Minimization of the adverse effects of natural resource development on the environment.

It should be noted that these sub-objectives are at times conflicting. For example, if resource revenues extracted from resource users were excessive, industry competitiveness in world markets, and hence long run viability, could be at risk.

Generation of resource revenues to the Crown is based on pricing and taxation approaches which vary according to the particular resource under consideration.

Taking into account the overall policy objective stated above, the various objectives of a natural resource pricing policy could include the following:

- to raise revenues to finance government resource management and development costs;

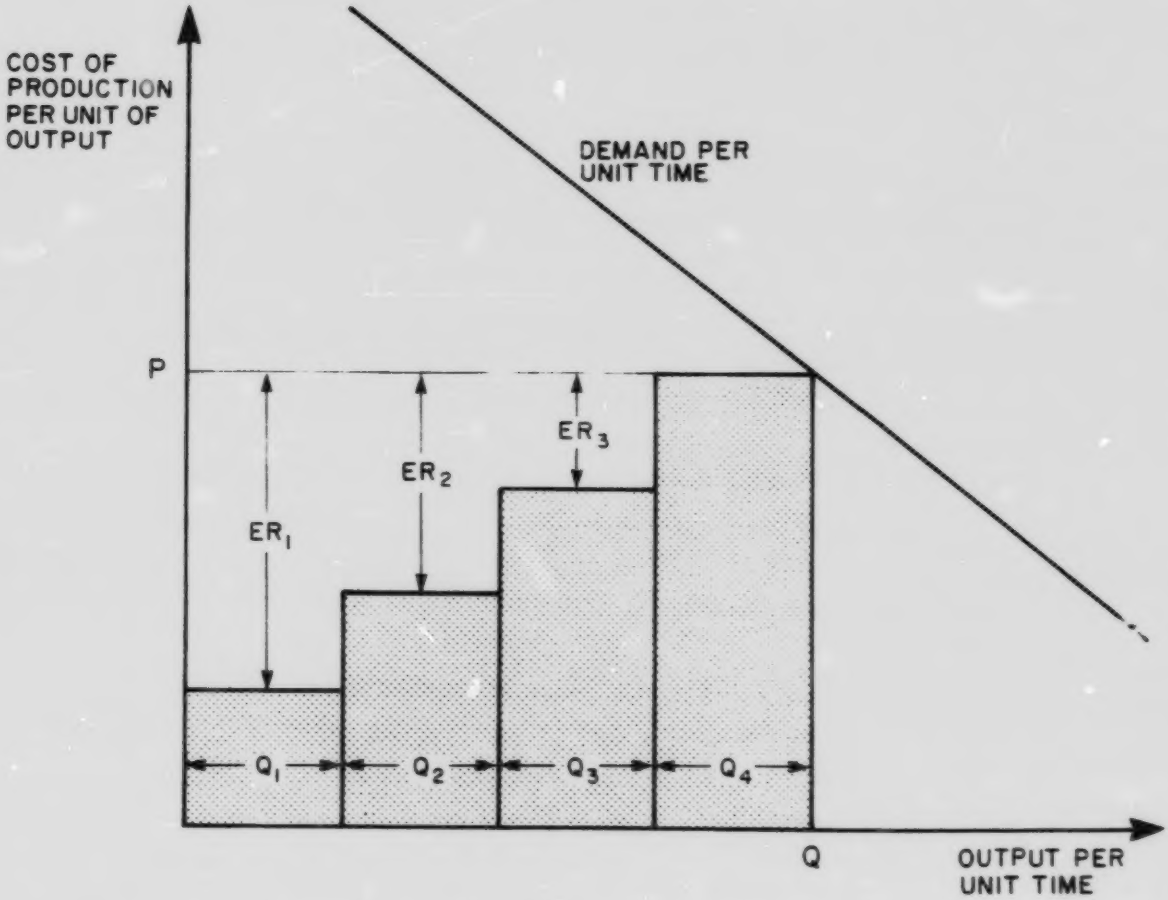
- to maximize revenues to the Treasury;

- to manage resource development and utilization

    - direct or re-direct regional usage patterns;
    - change patterns of usage by user category;
    - ensure efficient utilization of existing resources for present and future generations, including the recognition and amelioration of external costs imposed on society by the extraction of the natural resource (health impacts, environmental impacts, changes in traditional lifestyles).

EXHIBIT III-2

ILLUSTRATION OF ECONOMIC RENTS



Q = Quantity produced per unit time

ER = Economic rent

- to encourage conservation practices;
- to redistribute "excess" profits earned on the use of the resource (economic rents - see discussion below).

Economic Rents And The Pricing And Taxation Of Natural Resources

The term economic rent refers to the amount by which the price of a natural resource exceeds its cost of supply (including a "normal" return on investment). That is, economic rent is a financial return on a natural resource, over and above what would normally be required to bring the resource into production.

Exhibit III-2, opposite, shows a demand-supply situation in which, for simplicity, we assume that a resource is supplied from four separate locations. The "grade" or quality of the resource is different at each location, and consequently the unit production costs (which include normal returns on investment) also vary. The resulting industry supply curve in this illustration is thus a "step function". At a competitive equilibrium, marginal cost equals price and quantity Q is produced for a price of P per unit. All units are sold for price P. Thus, substantial economic rents exist for some units (e.g., the highest grade resource at location 1) while no rents exist for the "marginal" grade resource at location 4.

For resources such as timber, minerals, oil and gas, economic rents may vary depending on a variety of factors which influence production costs such as:

- location/access (transportation costs)
- size of deposit (economies of scale)
- grade, quality or concentration (unit production costs).

The existence of economic rents in natural resource production provides at least some of the rationale for the collection of taxes or royalties on behalf of the Crown, or the public, in which the ownership of the resources is vested. The economic rents may be thought of as the values of the resources "in the ground". The collection of some, or all, economic rents represents a payment to the resource owner for the use of the natural resource.

However, whether or not rents exist in a given instance, the Crown may still wish to charge for the use of a publicly-owned resource. That is, the charge would be applied to all units extracted, in order to recognize that a beneficial use of a crown-owned resource has taken place or to reflect social opportunity costs.

The determination of economic rents in practical terms is extremely difficult, if not almost impossible. Difficulties involve disentangling short and long-term price fluctuations, "normal" rates of return, and returns for risk-taking required to ensure continued exploration for new reserves. Other difficulties involve defining the specific costs which are involved in production.

Certain impacts of resource royalties and taxes can, in principle at least, be ascertained by considering their relationships to the levels of the economic rent. As long as the royalties or taxes applied to the units produced from a given location do not exceed the economic rents earned, then no change in production levels, or prices, should occur, since all factors are being adequately compensated. If the royalties or taxes are too great, decreases in production might occur. In particular, the "marginal" producer with no economic rent (location 4 in Exhibit III-1) may cease production eventually. In this case, there is no excess return, over that which is required to keep that location producing, out of which to pay the taxes.

Assuming that the operation of competitive markets results in the efficient allocation and use of scarce resources, then it may be desirable that the operation of tax collection schemes should not affect the production decision and consequent production levels and prices. That is, taxes in excess of economic rents should not be collected, if existing patterns of production are to be unaffected.

On the other hand, a resource price levied by government may be designed to recognize the full social costs related to its extraction (externalities). These could include environmental damages and public resource management costs. If this price exceeds the economic rents, requiring the producer to pass on some of this extra cost to the final consumer, then higher market prices and decreased production levels may result.

Various pricing/taxation mechanisms are used for natural resources in Ontario. Their impact can be assessed from many points of view, including the extent to which they tend to collect existing economic rents.

APPLICATION OF ECONOMIC PRINCIPLES TO THE PRICING OF RAW WATER

Rationale For Water Withdrawal Charges

Water, and water services, constitute an economic good, facilitating the many uses noted in Chapter II. Society's resources are consumed in the extraction of water for use. In addition, water itself has characteristics of scarcity at certain times and places.

Raw water is presently unpriced in Ontario. However, there are social opportunity costs associated with its use:

- In some cases, excessive withdrawals can reduce available flows below minimum requirements for other uses, resulting in damages or reduced utilization for competing uses.
- "Mining" of some groundwater supplies can lead to decreased availability for future users.
- The Province allocates public funds to water quantity management programs.

Thus, the zero price of raw water may lead to an inefficient allocation of society's resources. The pricing of water withdrawals is in line with the user pay principle in which the prime beneficiary of the use of an economic good should pay for the costs associated with its use.[11]

Response By Users To A Non-Zero Price For Raw Water

We consider raw water as a factor input to a productive process. If the price of a factor rises, relative to the prices of other factors, then the user will have an incentive to use less of the factor by substituting other input factors. The extent of reduction for a given price increase could be estimated with knowledge of the price elasticity of demand for raw water. Generally speaking there have been few empirical studies of the demand for raw water.[12] There is the need for more research in this area to support the effective formulation of raw water pricing policy.

For water prices to have an impact on the levels of withdrawal, it must be recognized that total water costs will increase with each further unit withdrawn. That is, the marginal price must not be zero (as is the case with some flat rate pricing schemes).

In summary, putting a price on water services will induce the user to treat water costs like other factors of production and thus make the most efficient use of his available resources. Further, if the price represents the social opportunity costs of the water withdrawal, an efficient allocation of society's resources will result.

Policy Objectives In Pricing Raw Water

We have discussed the principal economic benefits which can be derived from appropriate pricing of water services. If the price is based on the marginal social opportunity cost of supplying the resource, then optimal allocation of society's resources will result. From the perspective of the manager of the water resources and other natural resources, there are many other factors to be considered in implementing a pricing policy. Certain other objectives and political considerations may conflict with the allocative efficiency objective.

The policy objectives which may be achieved by a pricing scheme for raw water include:[13]

- Implementation of the user pay principle with regard to a publicly owned resource.
    - maximize revenues from the use of the resource (possibly exceeding the social opportunity costs generated by its use)
    - generate sufficient revenues to cover all or part of water quantity management costs.

- Water resource management:
  - ensure efficient utilization of existing water supplies, and of society's resources in making new supplies available for use
  - direct or re-direct regional consumption patterns, e.g., industrial location decisions
  - change quantities demanded by user class
  - keep water use inventory up to date
  - encourage conservation practices and the development of water saving technologies.
- Income redistribution:
  - redistribute, for example, economic rents occurring from the use of water
  - apply differential rates for different classes of users.

Approaches To Raw Water Pricing

The economic literature contains numerous studies and references on the pricing of delivered supplies of municipal water.[14] The prices charged rarely represent the marginal costs involved in the delivery system itself, either in the short run in terms of daily, or seasonal peak usage, or in the longer run in terms of adding new capital supply works, if present supplies are insufficient. The typical pricing system for water in Canada is based on recovery of costs (historical capital, and operating) through a "price equals average cost" approach. The marginal cost principle suggests that more efficient use of existing supplies would result if prices were set to reflect the costs of supplying the marginal user (although this may result in insufficient revenues if marginal costs are less than the average cost). The marginal cost approach could include differing rates for peak hour, or peak season users. If additional demands would require capital additions to the supply system, the appropriate rate would be based on the long run marginal cost of these extra supplies.

We are interested in the determination of a price for raw water. The application of the social opportunity cost concept would require an examination of the alternative uses which might be made of the water at a given place and point in time. For example, opportunity costs of a withdrawal use might include loss of habitat or recreational possibilities due to low flows, or buildup of reservoirs in some seasons. It may also be appropriate to include water resource management costs borne by the Crown.

The using up of available flow by a withdrawal use may impose a cost on other uses also competing for that flow. In principle, this is analogous to the external costs imposed on society by the emission of waste waters and the using up of assimilative capacity. This is particularly relevant in the case of competitive instream uses. The marginal "damages", i.e., costs imposed on the competing uses, relate to the values of water in those other uses. Estimating these values is sometimes extremely difficult (as is estimating the value of pollution damages). The value of water in instream uses is particularly difficult to estimate, since in most cases there are no direct monetary transactions. Muller (1985) has provided broad average values of water for Canada in the major categories of withdrawal and instream uses, relying on a variety of data and studies from both Canadian and other jurisdictions. It would be very difficult, for example, to apply these results for specific pricing situations in Ontario. Muller notes that recreation values are very site specific.

If it is determined that available flows in a drainage system are not adequate to supply the competing withdrawal uses, then a price may be set that will cause withdrawals to drop to desired aggregate level. This will result from the private cost-minimizing behaviour of users: when users are faced with raw water charges, they will consider the implementation of various strategies and options to reduce their charges, as long as the reduction technologies don't cost more. It can be shown that reduction in withdrawals will continue until the marginal cost of reducing withdrawals (through enhanced recirculation and water saving technologies) equals the price. This price level may be set if data are available on the marginal costs of installing and using such equipment. The level of reduction desired will be achieved at the least social cost. Overall efficient use of resources may not be achieved because the price was not set to the marginal social opportunity cost.

In summary, it appears difficult in practice to arrive at the true marginal social cost of the use of raw water. We have noted before, that the number of conflicts between withdrawal uses is limited in Ontario. In this sense, there are clearly many cases where withdrawal of water does not impose economic or external costs on other users and thus the social opportunity cost is zero. From this point of view, the appropriate price may be zero, unless water resource management costs are considered.

A further dimension to be considered, however, is the anticipated growth in future withdrawal demands. New instances of withdrawal demands may arise, which are in excess of supplies at given places and times. Taking a forward looking view, it may be appropriate for the Crown to apply prices now, as a signal concerning future social opportunity costs.

In principle at least, the existence of economic rents in the use of water may be used as a guide to pricing the raw water resource. The determination of economic rents is difficult in practice. Further discussion of this approach is deferred to Chapter VII.

Considering the economic principles elaborated above, and the possible objectives of rsource pricing schemes, we identify the following three possible approaches to setting prices for water withdrawals:

- Revenue Based: Prices are determined by specified revenue targets.
- Marginal Cost Based: For a desired level of water use reduction, the appropriate price can be determined if cost functions for water-saving and re-circulating technologies are known.
- Economic Rent Based: Prices reflect economic rents earned by users.

Applications of these approaches are discussed in Chapter VII.

APPLICATIONS OF ECONOMIC PRINCIPLES TO EFFLUENT CHARGES

Rationale For Effluent Charges

Surface waters are used to receive and carry away wastes from both mining/manufacturing/industrial sources and municipal sewage treatment plants. These services supplied by water may be considered as factor inputs to the respective productive processes. These services are currently obtained free in Ontario. However, there are social opportunity costs associated with wastewater discharges:

- Pollution damages can occur to the environment, and to human, other plant and animal systems.

- Other uses may be curtailed if water quality is inadequate.

- The Province allocates public funds to water quality management programs.

The lack of a price may lead to an inefficient allocation of society's resources.

Response By Polluters To An Effluent Charge

As in the case of raw water, a non-zero price on effluents will provide polluters with an incentive to reduce discharges. The strength of the incentive is based on the relationship between the price and the abatement costs which the polluter would incur to reduce emissions.

Policy Objectives In Effluent Charges

The policy objectives in charging emitters for waste water discharges could include:

- Implementation of the user pay principle with regard to a publicly-owned resource:

    - maximize revenues from the use of a publicly-owned resource

    - generate sufficient revenues to cover all or part of water quality management costs.

- Water quality management:
    - ensure the efficient utilization of society's resources
    - reduce emissions of point sources
    - achieve ambient quality objectives
    - encourage the development of pollution control technology.
- Income redistribution:
    - redistribute rents occurring from the use of scarce assimilative capacity
    - compensate victims of pollution
    - subsidize abatement programs
    - apply differential rates to different classes of users.

Approaches To Setting Effluent Charges

The literature is well developed with respect to discussions of social costs and optimal pricing for pollution emissions.[15] In the case of water, the social opportunity cost refers to damages or costs imposed on society due to reductions in water quality. The opportunity cost pricing principle is that the price per unit of discharged waste water or pollution should equal the value of "damages" and other costs due to that unit. They may be expressed, for example, as the cost of restoring the water to its former quality, or the value in other uses foregone due to the reduced quality of the water. In practice, these damages are a complex function of the quality of receiving waters and locational factors, and are extremely difficult to estimate satisfactorily. Where pollution is perceived to be causing severe impacts, it may be justified to allocate resources to the development of such damage functions.

Economists recognize another approach to this problem. The alternative is to set a price that causes reductions in discharges to reach a desired level, say in a given drainage basin or sub-basin. In principle, abatement in response to a price on discharges will continue until the marginal cost of abatement equals the price. Thus, the appropriate price level may be determined if data are available on the marginal abatement costs.

Even though marginal damage impacts are not known explicitly, the regulating agency specifies how much pollution can be discharged by setting the desired level of emissions. Although full allocative efficiency may not be obtained in terms of balancing damages with other inputs to the production process, it can be shown that the desired level of abatement will occur at the least total social costs.

Again, in principle, economic rents may exist in the use of assimilative capacity. The discussion of the extent to which this may be used as a guide in pricing is deferred to Chapter VIII.

Considering the economic principles, and the possible objectives of resource pricing schemes, we identify the following three possible approaches to setting prices for effluents.

- o Revenue Based: Prices are determined by specified revenue targets.

EXHIBIT III-3

LIST OF CRITERIA FOR THE EVALUATION OF PRICING SCHEMES

ADMINISTRATIVE CRITERIA

a. Incentive Effects:

- is there an incentive effect for the desired behaviour?
- are there any perverse incentives?

b. Information Requirements:

- for setup
- for continued operation.

c. Revenue Generation.

d. Costs of Administration.

POLITICAL CRITERIA

a. Compatability with the current system.

b. Scope for bargaining and delay.

c. Adaptability/Flexibility in the face of economic change:

- e.g., inflation.

d. Local Economic Impacts:

- plant closures, employee lay-offs due to charges.

SOCIAL BENEFIT CRITERIA

a. Allocative Efficiency or Cost Effectiveness:

- is the desired behaviour induced at the least social cost.

b. Equity:

- what is the incidence of charges on various sectors?

c. Incentive for technological innovation.

- Marginal Cost Based: For a desired level of abatement (corresponding to an emissions objective), the appropriate price can be determined if abatement cost functions for water-saving and recirculating technologies are known.

- Economic Rent Based: Prices reflect economic rents earned by polluters.

Applications of these approaches are discussed in Chapter VIII.

CRITERIA FOR THE EVALUATION OF PRICING SCHEMES

Peat, Marwick and Partners (1983, Chapter IV) developed a set of criteria for the evaluation of alternative environmental policy instruments focusing on pollution control policies based on economic incentives. The criteria were divided into three main categories: administrative, political and social benefits. There criteria are summarized in Exhibit III-3, opposite.

In Appendix B to this report, we have reproduced an adapted version of Chapter IV of the study noted above. In the main text of this chapter, we provide further comments on two very important criteria, those of allocative efficiency and equity.

Allocative Efficiency

As has been discussed above, allocative efficiency of a pricing scheme refers to the extent to which the use of society's resources is optimized. In the example of a raw water pricing scheme, the pricing mechanism equates marginal values in use and discourages any use with a marginal value less than the unit price. Society's net benefits are maximized when the price equals the marginal cost of the supply.

Certain concerns may arise if the allocative efficiency goal is pursued to the exclusion of others. For example, consider a situation where water supplies are extremely limited. A price could be devised so that existing supplies are just used up. However, the price may be so high, that only those with high incomes can afford to pay the price. This would likely be viewed as unacceptable from the political standpoint, and some other allocation method, such as quotas, might be adopted.

Pricing policy may have regard to efficiency over the longer time horizon. Suppose that scarcity of a particular water resource is anticipated with a reasonable degree of precision. Since prices affect future decisions of users, it may be appropriate to impose prices now, as a signal of increasing future opportunity costs.

Equity

The criterion of equity deals with the "fairness" of the application of the scheme in terms of the distribution of the burden of charges over various sectors and individuals in society. It is often concerned with the magnitude of charges in relation to the ability to pay. Thus, equity is often considered in terms of income and income redistribution.

The main groups of interest in equity considerations are:

- taxpayers
- shareholders and management of water using firms
- employees of water using firms
- water users
- consumers of goods produced by water using firms.

The particular income characteristics of schemes and considerations of equity are open to considerable subjective interpretation, and can vary from country to country, province to province, or even municipality to municipality.[16] For example:

- Income redistribution may be an objective in order to foster development in agricultural or industrial sectors through subsidized water prices.
- Social equity considerations sometimes motivate subsidized residential water rates in some jurisdictions so that lack of income will not affect the ability to meet a basic human need.
- Other equity concepts relevant primarily to municipal water supplies include:
    - parity: the notion that revenue per unit of service supplied is the same for each user group
    - equalization: the notion that an equal charge per unit of consumption is imposed on all users in a region, regardless of varying supply costs.
- It may be felt that charges should reflect users' ability to pay (income).
- Historic equity refers to the fact that existing users have sometimes made irreversible capital decisions on the basis of zero prices for water services, and therefore pricing results in an unfair burden. On the other hand, users who have just installed water saving equipment or abatement technology may feel that paying additional charges is inequitable.

NOTES FOR CHAPTER III

1. The concepts of value discussed in this section are described in such works as, for example, Samuelson (1980, Chapter 22) and Hirschleifer et al (1960, Chapter II) who deals with the concepts of value in the context of water and water use.

2. See Mishan (1982, Chapter 7) for a discussion of consumers' surplus.

3. Mishan (1982) provides a thorough discussion of the concepts of benefit-cost analysis.

4. These relationships can be shown by the following:

Suppose Revenue = Price x Quantity, i.e. REV = P.Q.

Differentiating with respect to P:

$$\begin{aligned}\frac{dREV}{dP} &= P.\,\frac{dQ}{dP} + 1.Q\\ &= Q.\left(\frac{P}{Q}\cdot\frac{dQ}{dP} + 1\right)\\ &= Q.\left(\frac{dQ/Q}{dP/P} + 1\right)\\ &= Q\,(e + 1)\end{aligned}$$

where e refers to the price elasticity of demand. This relationship can be used to demonstrate the following results:

- For e between 0 and -1, $\frac{dREV}{dP}$ is positive. That is, Revenue increases if price increases.
- For e equals -1, $\frac{dREV}{dP}$ is zero. That is, Revenue does not change when price increases.
- For e less than -1, $\frac{dREV}{dP}$ is negative. That is, Revenue decreases as price increases.

5. Samuelson (1980, page 525).

6. See, for example, Samuelson (1980, page 432 to 435) and OECD (1985, page 10), for elaboration.

7. Samuelson (1980, page 435).

8. See Baumol and Oates (1975, Chapter 3) for a discussion of externalities and optimal pricing.

9. The British North American Act, Section 92.5 provided the provinces with the exclusive power to make laws in relation to "the management and sale of public lands belonging to the province, and of the timber and wood thereon". The jurisdictional authority over water is less clear. See Pearse et al (1985, Chapter 6).

10. See, for example, Independent Task Force on the Development of Canada's Petroleum and Mineral Resources (1975, Appendix A, page 106) and British Columbia Ministry of Forests (1980, page 7).

11. Various discussions of the user pay principle can be found in the literature. See for example OECD (1975), United Nations (1980, page 84), United Nations (1983, page 24). Mention is also made in Pearse et al (1985, page 99) that ideal pricing systems from water "would require users to pay a price for the water they use at least equal to the costs of providing it".

12. In Canada, Renzetti (1986) has estimated price elasticities for industrial intake water, being a combination of both raw and public supplies.

13. See Power (1968). This paper is apparently the only discussion in the literature of the pricing of raw water through royalties in the Canadian context. It deals with objectives and approaches in setting royalty rates from the perspective of the management of a Crown-owned resource.

14. For an examination of Canadian practices, see Tate et al (1984).

15. See, for example, OECD (1985).

16. A discussion of various interpretations of equity can be found in OECD (1985, pages 13-15).

IV - NATURAL RESOURCE PRICING AND TAXATION IN ONTARIO

In this chapter, we investigate the approaches used by the Ontario government in collecting royalties and taxes on the use of crown owned natural resources. First, we discuss the characteristics of natural resources and various approaches used in collecting royalties and taxes. Next, we consider the pricing and taxation systems which have developed for timber, minerals and natural gas and water for hydroelectric power generation. Finally, we consider the application of these pricing and taxation mechanisms to water.

CLASSIFICATION OF NATURAL RESOURCES

According to the Canadian Encyclopedia, Hurtig (1985), "resources" may be classified under the following headings:

Information and Availability Characteristics

- Potential reserves of resources are thought/suspected to exist.
- Conditional reserves are known to exist but their availability depends on a number of factors, primarily available technology and appropriate selling price.
- Current reserves are in production now.

These descriptions would seem to most appropriately refer to non-renewable resources (as defined below) such as minerals. It is conceivable, however, that certain groundwater supplies could be considered as non-renewable, and be described by these categories.

Temporal Characteristics

- Renewable resources regenerate in short periods of time, or are characterized by repeated occurrences. These are most often biological resources:

    - animals, fish: regenerate in small number of years
    - forests: regenerate in decades
    - water: regenerates or re-occurs in weeks or months.

  Renewable resources rely upon atmospheric and cyclical processes that occur repeatedly. Different regeneration periods require differences in resource management.

- Non-renewable resources can not be regenerated in a human life span. These include minerals and land and some groundwater deposits. The quantities of non-renewable resources in an inventory at a given point in time will reflect the current information and availability characteristics noted above.

Spatial Characteristics

- Mobility. Mobile resources include air, water, wildlife and aquatic life. These resources may, at times, present inter-jurisdictional problems.

- Concentration. This will affect the extent of processing required for their extraction. Concentrated resources could include minerals and waterbodies. The degree of concentration of minerals, combined with a given extraction technology, may determine whether they move from a conditional to current resource at a given point in time.

Ownership Characteristics

The resource may be owned privately, publicly or as common property. In Ontario, natural resources are owned by the Crown which gives rights to their use by licence, permit, lease or outright sale.[1]

ALTERNATIVE METHODS OF NATURAL RESOURCE PRICING AND TAXATION IN ONTARIO

In this section we describe, in general terms, a number of approaches to the collection of natural resource revenues. Subsequent sections describe, in more detail, the approaches used in Ontario for pricing timber, minerals, natural gas, and raw water for hydroelectric power generation. Most of this material is based on personal interviews, and in some cases on published reports. These are referenced where appropriate.

Severance Tax Or Royalty On The Amount Of Resource Removed

This approach can be considered a "price" approach in which the Crown charges each producer a price of x dollars per unit extracted. Total revenues are therefore strictly related to volumes of production, rather than market price received or profitability of the producing operator.

In practical applications, a set of prices may be applied, based on the grade or quality of the resource, and perhaps the end use of the resource. An indexed variation of this approach is used in Ontario for the collection of timber revenues.

- Advantages. A major advantage of a severance tax or royalty is one of simplicity of application. Production levels can easily be ascertained. The total taxes collected will be proportional, ultimately, to the "size" of the resource. Revenues do not depend on the profit levels of producers. A perception of equity is engendered by having a uniform charge, payable by everyone.

  One of the most important advantages of this system is that consumption levels of the resource may be influenced by the level of the royalty. Generally speaking, if the market price of the final product is increased due to the royalty, consumers will likely use less, depending on the elasticity of demand. This feature may be important if it is desired to promote more efficient use of the resource, to implement a conservation policy, to acknowledge that there is an alternative valuable use to the resource, or to ensure that the full social costs, including externalities, are being paid for.

- Disadvantages include:

  - Difficulty in fixing the royalty schedule

  - High grading may occur (for example, cutting only the most desirable trees from a given stand, leaving behind a less desirable mix of trees) and the levels of production may be distorted to the extent that the severance tax or royalty does not reflect variations in levels of economic rent inherent in locational and grade factors. This system will tend to eliminate the marginal producer.

- Although a perception of equity was noted above, a uniform royalty rate will capture various proportions of existing economic rents, and thus would not capture taxes or royalties in relation to the operator's ability to pay out of economic rents. The most profitable resources in fact pay the lowest proportion of the related economic rents.

- This system may over-collect in years in which markets are depressed. That is, although no economic rents may exist in some years when market prices are low, the taxes will still be collected. Thus the operator's tax burden may be relatively heavy in poor years.

Severance Tax or Royalty Based On A Fixed Percentage Of Sales Revenues

In this system, x% is charged per dollar of sales. The advantages and disadvantages of this system are similar to those listed above for the uniform tax on production, except that revenues vary with market prices as well as production levels. This may be an attractive feature when market prices or consumption are increasing. On the other hand widely fluctuating market prices would likely cause revenues to fluctuate as well. This approach is used in Ontario in assessing royalties for natural gas production on Crown lands.

- Other advantages include:
  - from the perspective of producers, they may pay less when prices or consumption are depressed, perhaps reflecting reduced rents
  - taxes reflect the operators' revenues.
- Other disadvantages include:
  - difficulty in fixing the severance tax or royalty percentage
  - it is possible for two producers to pay different royalties on the sale of the same product, thus leading to a potential perception of inequity.

Taxes On Income Or Profits

In this approach, a percentage tax is applied to the "profits" derived from the actual resource extraction operation. Tax payments are thus proportional to economic rents earned. The system may or may not preserve marginal resource operations earning little or no economic rents, depending on whether an allowance is made for a reasonable rate of return.

An income or profits-based tax approach may be preferred in a resource industry in which there is a high degree of risk (e.g., mining) so that operators are not penalized for having made a poor decision in committing resources to a particular resource location.

A major variant on this scheme is a graduated or progressive schedule of marginal tax rates which increase as profits increase. Most mineral activity in Ontario is taxed under this system.

- Advantages include:
  - implicit recognition of varying grades of resource being extracted
  - recognition of risk in resource extraction operations
  - recognition of the ability of producers to pay
  - a scheme with progressive rates of tax could capture a higher proportion of "windfall" profits due to large price increases.
- Disadvantages include:
  - the Crown implicitly shares in the risks of private enterprise, and any possible corporate mismanagement
  - if the "profits" are determined after an allowance for a reasonable rate of return, there will likely be no need for producers to pass on extra costs, and therefore no incentives for consumers to reduce consumption
  - a single rate of tax may leave uncollected high rents on the most valuable resources
  - progressive tax rates tend to discriminate against large deposits of marginal grade. Where many operations are required to be aggregated for tax purposes, the progressive tax may discriminate

against large companies. Progressive rates may also discriminate against the efficient operator

- in mining and forest operations, it is very difficult, in some cases, to ascertain costs and revenues which pertain strictly to the extraction operation. This is particularly true of large integrated companies with extraction, processing and fabricating activities. Income or profits-based taxes provide many opportunities to deduct costs and therefore reduce taxable income. From this perspective, the profits tax approach may be cumbersome to administer

- government revenues will fluctuate with the business cycle.

Royalty Based On Volume Of Final Product Produced or Sold

In this case, a charge is applied to each unit of final product sold, rather than to the unit of resource being used as an input. This approach is being used in Ontario with respect to the utilization of land and its associated water flows to generate hydroelectricity. The charges are known as water power rentals and are applied to power utilities, and to privately owned power plants. Water power rentals are a combination of a variable charge based on the amount of electrical energy supplied (KWH), and a fixed charge based on the capacity of the generating plant (KW).

To the extent that production of electrical energy is a direct function of the quantity of water used, the variable charge approximates a charge per unit of water.

In other possible applications where a resource is an input to the production of a final product, the quantity of input per unit of output will vary from time to time, producer to producer and industry to industry. To be equitable, then, different charge rates would likely be required for different producers/industries.

- Advantages:
  - this scheme is simple to administer in the case of hydroelectric power generation.
- Disadvantages:
  - in most applications, it would be costly and time-consuming to develop the necessary diversity of charge rates per unit of output required to provide approximately the same level of revenue per unit of raw resource
  - thus, if a uniform rate is applied to all producers of a homogeneous commodity, inequities will likely occur as reflected by the various implicit royalties per unit of input.

TIMBER PRICING IN ONTARIO

Timber revenues consist of area charges and stumpage.[2] Area charges relate to rentals on productive land licenced for cutting. Stumpage consists of a number of charges and revenues related to the volume of the timber actually cut, including:

- Crown dues: statutory charges applied to all timber cut, based on either a volume or weight measure. About 90% of stumpage consists of Crown dues.

- Bonus: is a negotiated charge, in addition to Crown dues, to recognize the high quality or accessibility factors of a particular stand of trees.
- Revenues from tendered bids: revenues from competitive bids for the right to cut a specified stand. These are paid over and above Crown dues and bonus.

The current schedule recognizes four "grades" of timber including:

- all softwoods
- two grades of hardwood
- fuelwood.

In addition, two schedules of Crown dues are in effect for each grade, depending on whether the timber operator is integrated or non-integrated. An integrated timber operator also owns or is affiliated with a pulp mill.

Timber revenue generating mechanisms have been subject to considerable scrutiny in Ontario since the mid-1970's, resulting in several major changes aimed at increasing revenues:

- Doubling of Crown dues in 1974 from 1973 levels, pending the Report of the Timber Revenue Task Force in 1975.
- The Timber Revenue Task Force recommended a "single indexing" of Crown dues approach which was implemented in 1978, retaining the 1974 doubling. "Single indexing" refers to a method of escalating Crown dues, based on the growth in the appropriate Statistics Canada selling price index.

- The 1982 Timber Revenue Review Group recommended a further increase of 25% in Crown dues, and the "double indexing" procedure. These were both implemented in 1984.

  Double indexing refers to a compounding procedure for escalating Crown dues, based on the appropriate Statistics Canada selling price index. For example, if the index grew at a rate of g% per annum, this would translate to a (compound) growth rate for the Crown dues of $100\ ((1 + g/100)^2 - 1)$. With this formula, an increase of 5% in the Statistics Canada index would result in an increase of 10.25% in the Crown dues.

The rationale for these various price increases was based on:[3]

- A steady erosion of total timber revenues as a percentage of the selling price of lumber products.
- The desire to generate additional revenues in recognition of increased forest management costs. This was particularly prominent in the 1982 review where substantially increased costs due to Forest Management Agreements were beginning to be experienced.
- The desire to realize returns comparable to other jurisdictions.
- Indexing of Crown dues makes operators' charges responsive to price changes (both up and down), so that more recognition is given to operators' ability to pay.

- In a background report to the 1975 Task Force prepared by the Ministry of Natural Resources (1974, page 31), it was noted that conflicts between timber production and recreational uses of forests had been increasing. It was suggested that one of the reasons for the doubling of Crown dues was the recognition that "allocation of the scarce forest resources must be done on the basis of the opportunity cost of the resources in other uses". Forestry industries must be willing "to pay greater amounts for cut trees than other users are willing to pay for keeping them standing". It was noted that revenues from parks, fish and wildlife were almost equal to timber revenues. It was also recognized that timber production and other uses are not necessarily mutually exclusive, and that for most of the life of a given stand (to the time of cutting), these uses are complementary, rather than competitive.

Additional comments on the current system include:

- Due to the "compound" nature of the double indexing procedure, Crown dues could escalate significantly in a period of sustained, large price increases.

- It attempts to recognize efficiency and profitability differences with different Crown dues schedules for integrated and non-integrated companies.

- The system is fairly straightforward to administer.

- "Grade" variations are recognized (four levels).

- Area charge rates have also increased significantly in the last ten years. It is desired that area charges provide about 10% of total timber revenues.

It should also be noted that, in addition to stumpage and area charges, a logging profits tax on woods operations was implemented in 1950 to increase timber revenues, and abolished in 1972. Difficulties with this system included:[4]

- Difficulty in assessing logging profits in integrated operations.
- Administratively cumbersome, coupled with relatively low revenues.
- It was difficult to say whether the combined total of logging tax and stumpage collected "equalled the fair provincial share of economic rent".

MINING TAXATION IN ONTARIO

Ontario Mining Tax is levied on income derived from (metallic) mining operations at a progressive set of marginal rates of taxation ranging from 0% (up to $250,000) to 30% for profits in excess of $20 million.[5]

Generally, profits from all Ontario mines operated by the same taxpayer or related taxpayers must be aggregated for purposes of calculating mining tax under the graduated rate schedule. However, profits from certain operations may be taxed separately (for example, new mines brought into production after April 9, 1974).

Income or profits derived from mining operations is generally determined by taking the gross revenue received from the sale of the output of the mine (either in a primary or processed state) and deducting therefrom specific costs and expenses, including:

- costs of production
- most processing costs and transportation costs
- depreciation at prescribed rates
- certain exploration and development expenses
- processing allowances at prescribed rates
- operating and maintenance costs of certain "social" (or townsite) assets in Ontario.

Principal difficulties in the administration of this system revolve around the determination of revenue and cost items associated with the mining operation alone. The Ontario Mine Assessor has ultimate responsibility for these determinations.

The Crown shares in the risks of mining, in terms of fluctuating revenues, without sharing in the decision-making process.

The last major change to the Ontario Mining Tax Act was in 1975. Various aspects of the Act are now under review. One of the purposes of the review is to streamline its application and speed up tax assessments.[6]

Other revenues associated with mining include fees for mining claims, rentals for mining land leases and acreage taxes. These are small relative to the taxes levied on mining profits.

Various royalties and fees are collected for extraction of such resources as sand and gravel, salt and other non-metallic minerals. For example, a royalty of 30¢ per cubic yard is charged for the removal of sand and gravel from surface Crown lands. For salt mining operations, a percentage of sales approach is used: 1 1/2% of the sale price, FOB the processing plant. The amount of revenues from these activities is small relative to the mining taxes described above, although for sand and gravel and salt, the total revenues are in the neighbourhood of $1 million per year.[7]

NATURAL GAS ROYALTIES[8]

Natural gas is produced in Ontario from Crown land which is located only on the bottom of Lake Erie. (No oil is produced on Crown lands.) At the current time, a royalty of 12 1/2% is payable on the gross well head sales value of the gas, determined as the "Eastern delivered price", less certain cost items, including processing, transportation and quality factors.

The rate of the royalty is generally based on similar payments made by producers to private land owners.

The rate increased to 12 1/2% from 5% in 1981, when gas prices were increasing significantly.

Producers are responsible for measurement and reporting of sales volumes and royalties due. No auditing of these reported values is carried out.

The deduction of certain cost/quality items, and the fact that the royalty rate increased with a sudden increase in selling price, show that recognition is being given to the existence of differing levels of economic rent.

WATER POWER RENTALS IN ONTARIO[9]

The Province has Water Power Lease Agreements with producers of hydroelectric power, including Ontario Hydro and many privately-owned power producers. Historically, these agreements called for annual rentals which were based on the amount of electric energy generated. The quantity of energy generated is a direct function of the quantity of water passing through the facility, so that, in effect, the rentals were related to the available flows of water in the bed of the waterbody. The unit rates were adjusted annually to reflect changes in the consumer price index.

As of June 1984 a new power lease agreement has been negotiated with Ontario Hydro which has effectively tripled their water power rental payments. Rates for other power generators have not yet been renegotiated but are under consideration. (The new 1984 rate was $16.50 per average annual horsepower, where average annual horsepower equals total KWH generated in the year, divided by the number of hours, i.e., 8,760, multiplied by a conversion factor .746.)

A further change in the Ontario Hydro Lease agreement has been to base part of the rental on the fixed capacity of the facility. The purpose of this is to encourage modernization and increased utilization of existing facilities. (A fixed capacity charge would imply that if capacity utilization for a given facility were low, the average cost per generated KWH would be relatively higher. There is, therefore, an incentive to increase utilization rates, and modernize existing plans.)

Recommendations which led to these changes were developed in 1981 by the Ontario Task Force on Water Power Rental Rates.[10] This study was conducted at a time of increasing world oil prices. There was recognition that a power system based on a significant proportion of water power is "cheap" energy in the light of oil prices, and that, perhaps, too low a value was being placed on the Crown water resource. In effect, the benefits of the use of water were going to (major) power users. It was felt that by increasing the revenues to the Crown for the use of this water, a more equitable distribution of benefits to the population could be achieved.[11]

This rationale can also be viewed in terms of economic rent. The concept of economic rent can be reworded to include the production of a product which depends on a given resource for an input. Economic rent exists when the market price, based on the cost of producing the marginal unit, exceeds the average cost of other methods of production or of other lower cost producers or suppliers. In the case of electric power, the marginal unit is usually produced by thermal means, which are more costly than hydroelectric generation. Thus economic rents exist. (In Ontario, most capacity growth in recent decades has been in thermoelectric generation, since the lower cost hydroelectric sites have been previously exploited.) The price charged to users (which is based on average production costs, including both hydroelectric and thermoelectric power generation) is lower than the marginal costs of producing electricity which, in a competitive market, would approximate the price. Therefore, some of the economic rents which do exist on the production of hydroelectric power are received in the form of lower rates paid by users. Increasing the water power rentals can be thought of as collecting rents from users and redistributing them, through the Crown, to the citizens of the Province.[12]

A recent study for the Economic Council of Canada by Zuker and Jenkins (1984) has shown that substantial economic rents exist in Canada with respect to hydroelectric power generation. The magnitude of these rents was estimated, based on what power would have cost if it had all been generated by thermoelectric means.

COMPARISON OF REVENUES FOR (SELECTED) NATURAL RESOURCES

The relative magnitudes of revenues to the Crown for the resources discussed above can be seen from the following table:

REVENUES FOR 1984-85
($ million)

Timber	61.0
Ontario Mining Tax	64.5
Natural Gas Royalties	4.9
Water Power Rentals	67.4

Sources

- Timber, Ministry of Natural Resources (1985, page 27)
- Ontario Mining Tax, ibid, page 51
- Natural Gas Royalties, Ministry of Natural Resources, Financial Branch
- Water Power Rentals, Public Accounts for Ontario, Vol. 1, Financial Statements, 1984-85.

IMPLICATIONS FOR WATER RESOURCE PRICING

Water As A Resource

From many perspectives water is a renewable resource. The hydrologic cycle ensures a continuous renewal of surface water resources and most groundwaters. In Ontario, annual precipitation is abundant and, in most years, seasonable patterns are not too pronounced. "Dry" years do occur, however.

We have characterized the water resource in terms of its two major attributes:

- o available flow
- o assimilative capacity.

Naturally available flows are essentially renewable. However, we have noted that available flows can, in some instances, be "depleted" if competing withdrawal uses are unregulated. Nonetheless, these flows can be easily restored by cutting back on withdrawals (although damages which might occur to dependent ecosystems due to low water levels may not as easily be reversed).

More importantly, we have noted that assimilative capacity can be reduced. It is, for example, increasingly difficult to find potable water not requiring pre-treatment. The ability of some waters to assimilate further quantities of certain pollutants is decreasing. In this sense, the quality characteristic of water may be considered non-renewable in some cases. Thus, water flows on the one hand are essentially renewable, while the assimilative capacity of waters for some pollutants may be non-renewable.

In the broadest sense, water is not destroyed in use. Waters are sometimes consumed in use, in the sense that they are lost to the watercourse from which they were withdrawn. They generally re-enter the hydrologic cycle, however, perhaps in a different drainage basin. However, as noted, one or more of its services may be depleted, or damaged. Because water itself is not destroyed in use, it may be used by successive users and some uses may occur simultaneously (e.g., fish life support and recreation).

Given these attributes of water, it is clear that it is not directly comparable to timber, minerals or natural gas. For example, each of these is fixed in location, and thus can only be extracted once. Utilization of these resources thus entails the extraction of specific chunks of matter, while for water, utilization may more appropriately be thought to involve a given flow and quality at a given location at a given time.

The economic values of water in various uses have been estimated to be substantial.[13] Given that water resources are vested in the Crown, and that at least one of its attributes may be considered non-renewable, there is a rationale for imposing charges for the use of water.

We have noted above that one use of water is, in effect, already being charged for in Ontario through water power rentals. Its value in hydroelectric power generation in relation to more expensive modes of power generation has also been recognized. Increased water power rental rates have been aimed, at least in part, at capturing for the public of Ontario a higher share of the value of the resource in this use.

Application Of Other Resource Pricing Approaches to Water

In this section, we consider cursorily the potential application of the various approaches now in place in Ontario which have been described in this Chapter. Detailed discussion of potential water pricing schemes is deferred until Chapters VII and VIII.

- Specific charge per unit extracted:
  - Could be applied to any direct water withdrawal use since quantities could be measured. Possible variants include charges for all water utilized, or only that portion consumed.
  - Can not be applied for instream uses (other than hydroelectric power generation) in which quantity used is not a meaningful concept.
  - On the assumption that decreases in assimilative capacity are directly proportional to waste dis-

charges, could apply a charge per unit of waste for municipal and industrial uses.

- Percentage of Sales Revenues

  - The concept of sales of water is appropriate only to the municipal use, in which treated water is sold to residential and industrial users.

  - Both withdrawals and discharges by municipalities could potentially be charged for.

- Taxes on Income or Profit

  - There is no application of this approach. Municipalities do not make profits. For other users, there is no "water operation" which can be isolated from their other activities, and to which revenues can be attributed, since there are no direct markets for water.

- Specific charge per unit of final product

  - This could be applied to industrial users. It could cover both withdrawals and discharges.

  - However, it would seem that it should be based on the required inputs of each per unit of end product. Therefore, it would appear to be not significantly different in approach from the charge per unit extracted, discussed above.

Summary

Water is a valuable public resource with many uses based on its two main attributes: available flow and assimilative capacity. Amongst natural resource pricing and taxation approaches currently in place in Ontario, charges for amounts used (including waste discharges into receiving waters) are the most applicable to water. A percentage of sales approach is conceptually applicable only to municipal water use.

NOTES FOR CHAPTER IV

1. The British North American Act, Section 92.5 provide the provinces with the exclusive power to make laws in relation to "the management and sale of public lands belonging to the province and of the timber and wood thereon". The jurisdictional authority over water is less clear. See Pearse et al (1985, Chapter 6).

2. Most of the material on timber pricing in Ontario is based on personal interviews with Mr. A. Nausedas, Ontario Ministry of Natural Resources. Other sources are noted.

3. Id.

4. See Ontario Ministry of Natural Resources (1975, pages 23, 24).

5. See Price Waterhouse (1983, page 12).

6. Personal communication with Dr. G. Anders, Ontario Ministry of Northern Affairs and Mines.

7. Personal Communications with Mr. J. Smith, Ontario Ministry of Northern Affairs and Mines.

8. The material in this section is based on personal communication with Mr. S. Keen, Ontario Ministry of Natural Resources.

9. The material in this section is based on personal communication with Mr. A. Frame, Ontario Ministry of Energy.

10. See Ontario Task Force Report on Water Power Rental Rates (1981).

11. This background is from personal communication with Mr. A. Frame (see Note 9).

12. Illustrative calculations of the distribution of economic rents are contained in the Ontario Task Force Report on Water Power Rental Rates (1981, pages 12 and 13).

13. See Muller (1985) for the estimation of the economic value of water in the major uses:

    - Indirect withdrawal uses:
        - municipal
        - agricultural
        - thermal power cooling
        - manufacturing.
    - Indirect instream uses:
        - hydroelectric power generation
        - wate assimilation
        - navigation and fishing.
    - Direct instream uses:
        - recreation.

V - EXISTING WATER PRICING SCHEMES EXAMPLES AND CRITIQUES

INTRODUCTION

In this chapter, we provide descriptions and evaluations of water pricing schemes which we have identified in the economic literature and in interviews with government personnel in various jurisdictions.

The interview process was not exhaustive or formalized. In some cases, especially in regard to our evaluation comments, we have had to rely on our own judgement in forming conclusions. We provide references wherever possible, however.

The focus of this study is on resource pricing schemes for raw water, rather than on end-use pricing. The literature contains many studies which examine pricing schemes for publicly supplied water delivered to residential, institutional, commercial and industrial users.[1] The price of delivered water to these users is most often an average cost per unit based on financial costs consisting of historical capital costs and current operating and maintenance costs. In general, users are being charged neither the short run nor the long run marginal costs associated with their water usage. Raw water, as an input to the production of delivered water, has a zero price.

The following sections describe selected pricing schemes and provide summary evaluations based on the evaluation criteria set forth in Chapter III and Appendix B.

WATER POWER RENTALS

We have discussed in some detail in Chapter IV aspects of the Ontario Water Power Rental Agreements system. Water for hydroelectric power generation is not usually thought of as a withdrawal use, but rather as an instream use. In principle, however, measurable quantities of water are used. The charges nominally are rentals for the use of crown lands and their associated water flows.

In Canada, the Federal government and all provinces, except Prince Edward Island and New Brunswick, collect some form of water power rentals.[2] Exemptions vary from place to place and charges vary with various combinations of the following elements:

- charges which vary with outputs
- charges based on installed capacity
- charges relating to reservoir storage.

Evaluation

It appears that revenue generation is an important component of water power rental schemes. It was noted in Chapter IV that substantial economic rents are associated with the generation of "cheap" hydroelectric power in Canada and that most of these benefits are received by power users in the form of low power rates. Water power rentals collect some of these rents and redistribute them to the public.

Equity considerations may therefore play a role in the determination of the rental rate. It was noted in Chapter IV that the 1984 increases in Ontario Hydro's rental rates were a partial reflection of the desire to obtain for the public a greater share of the existing economic rents.

The higher rental rates were anticipated to result in increases in Ontario Hydro's bulk power rates.[3] The higher bulk rates would be expected to result in higher prices for end users. Since electrical bills vary with the quantity used, there would be an increased incentive to reduce usage. This would perhaps have the impact of reducing the extent of (fossil-fuel fired) thermoelectric power generation since marginal supplies are generally provided by thermoelectric sources. This could ultimately avoid the construction of new thermoelectric facilities or result in less consumption of fossil fuels, such as coal.

WATER CHARGES, PROVINCE OF NOVA SCOTIA[4]

The Nova Scotia Department of Environment applies a declining block rate schedule of fees to holders of water withdrawal licences, primarily industries and municipalities. The fees are usually set for 20 years and are generally based on the maximum allowed withdrawal, as stated on the licence. In a few cases (for example, the City of Dartmouth) licencees may pay less if they meter themselves and show that useage was less than allowed. Licencees are not generally metered or audited. Most licences are for surface waters, although significant numbers of Nova Scotians use groundwaters. Fees have recently been dropped for agricultural uses for a combination of reasons including the fact that not all such users were licenced, and that the usage was generally less than the minimum volume charged for. Availability of supply is not a problem at present, even for groundwaters. Sometimes, there are conflicts in irrigation uses in the Annapolis Valley, but these are worked out by mutual compromise.

Evaluation

Generally speaking, the licencee has no incentive to reduce usage in a given year since the marginal price is usually zero (i.e., the fees are fixed for a given year since they are based on the maximum authorized volume of withdrawals).

In the longer term, marginal prices may be non-zero for charge schemes based on maximum authorized volumes. For example, a user could demonstrate decreased water requirements and could renegotiate his authorization downward, therby reducing his water bill. In the case of Nova Scotia, there appears little evidence that this has happened. It would appear that the strength of this incentive is very low, based on the fact that total water charges, including water power rentals amout to only a few hundred thousand dollars per year.[5]

The charge scheme would appear to play no role with respect to allocative efficiency. Users take as much water as they need. There is no scarcity of supply. Conflicts which do arise are settled by mutual agreement.

WATER CHARGES, PROVINCE OF SASKATCHEWAN

Saskatchewan Water Corporation applies a set of Industrial Water Use Charges based on the volume of withdrawals (acre feet) from both surface and groundwaters. The rates are as follows:

The rates are as follows:

- $15/acre-ft. $(\$12.16/10^3\text{m}^3)$ for withdrawal from the South Saskatchewan or Qu'Appelle Rivers.
- $3/acre-ft. $(\$2.43/10^3\text{m}^3)$ for any surface or groundwater with TDS less than 3,000 ppm concentration.
- $1/acre-ft. $(\$0.81/10^3\text{m}^3)$ for any surface or groundwater with TDS greater than 3,000 ppm concentration.
- Certain groundwaters free (Blairmore).
- In thermoelectric power generation, the amounts of discharged water lost through "forced evaporation" (by

being at a higher temperature), or consumed in the process itself, are estimated as 0.3 gal. per KWH generated. After conversion to acre-feet, a charge rate of $5/acre-ft. ($\$4.05/10^3 m^3$) is applied. This is not a water power rental, but is considered an industrial water use charge.

The water user provides the metering and is audited occasionally at most. The schedule of rates is the same for all users.

Evaluation

The rates have not changed since 1968 and are considered too low at the present time.[7] Total revenues generated from industrial users are nominal. It is felt that the low rates provide no incentives to change patterns of usage because the resulting charges are insignificant in relation to the total costs of users.

The differential rates were intended to encourage certain patterns of withdrawals. For example, a lower charge rate for higher concentration TDS was intended to provide an incentive for large users of groundwaters to drill and pump from lower depths, where concentrations are higher. However the differential rate is not great enough, so that users will still pay charges for the higher quality water at shallower depths. Generally, the rate structure is providing no incentives to change or reduce usuage patterns because of the overall low level of rates.

From an allocative efficiency point of view, these fees are therefore having little or no effect.

WATER CHARGES, PROVINCE OF BRITISH COLUMBIA[8]

All surface water uses which can be measured by volume used are licenced and assessed an annual fee by the British Columbia Ministry of Environment. Water power rentals are included. The fees are thought of as royalties, or rentals of crown resources. Except in the cases of municipal withdrawals and water power rentals, the annual fee is based on the maximum consumption allowed, as stated on the licence. Usage is generally not metered. For municipal water takings, charges are based on volumes withdrawn. Industrial water rates are a function of the particular industry. It was stated that the rates are reflective, in general terms, of the relative values in use, by industry, although the rate structures are largely the result of historical evolution. No fees are charged for groundwater use.

Evaluation

Revenue generation has apparently become more important as rates have approximately doubled in the early 1980's, bringing annual revenues to about $2 million. The system is simple to administer. For industrial uses, there is no short term price incentive to reduce consumption, since the annual fee is fixed, nor is it indexed. There may be longer term incentives to reduce consumption through the renegotiation of the maximum authorized withdrawal stated on the licence. In the case of municipal withdrawals, incentives to reduce consumption depend on whether residential users are metered and charged on the basis of usage.

OTHER EXAMPLES OF WATER WITHDRAWAL PRICING

OECD (1985) contains notes on the pricing of water withdrawals in several member nations:

- Japan:[9]
  - annual charges for surface waters only related to authorized withdrawals

- rates vary according to activity, location on the river; however, variations showed no economic rationale

- objectives are "equity of burden" and revenue generation for resource management.

o England and Wales:[10]

- Regional Water Authorities levy annual charges on authorized withdrawals

- variations in rate include degree of consumption as defined in Chapter II (5 categories), source of supply, season

- domestic and non-spray irrigation are exempt

- revenues are earmarked to meet costs of developing supplies.

o France:[11]

- charges are assessed on a regional basis

- quantity charges relate to actual withdrawals and in some cases to consumption (determined by coefficients applied to withdrawals)

- other variations include surface/groundwaters, season, water quality (14 zones)

- rates are higher where population and industrial density is higher
- revenues contribute to the resource management.

o United States:[12]

- in the Delaware River Basin, water consumed was charged at 100 times the rate for water withdrawn and returned
- in the saline lower portion, no charges
- revenues are used to repay dam works investment.

Evaluation

These schemes are largely aimed at revenue generation. In the case of France and the U.S. examples, some incentives exist for reducing water use where charges relate to actual withdrawals and consumption. It is also stated that there is some evidence in Japan that higher rates have discouraged industrial location in some zones.

SUMMARY

The water pricing schemes discussed in this Chapter (excluding water power rentals) are most often focused on revenue generation. Certain schemes are designed to provide incentives for changing withdrawal patterns, or for reducing withdrawals. However the strength of the incentives is weakened by:

- Charge rates resulting in total charges which are a small proportion of total costs faced by users.
- Charge rates which have not kept pace with inflationary pressures.
- The focusing on long run incentives, rather than short run incentives.

Water power rentals focus on revenue generation for the Crown, by the means of redistributing economic rents resulting from the less costly hydroelectric means of generating electric power. Water power rentals result in incentives to the end user of electricity to reduce consumption.

NOTES FOR CHAPTER V

1. See for example, Tate et al (1984), for a description of pricing practices in Canada.

2. For a brief summary of the charge rates for each scheme, see Environment Canada (1985).

3. Ontario Task Force Report on Water Power Rental Rates (1981, page 20).

4. Personal communication, Mr. J. Theakston, Nova Scotia Department of the Environment.

5. Id.

6. Personal communication, Mr. L. Jones, Saskatchewan Water Corporation.

7. Id.

8. All the information in this section was provided by personal communication, Mr. D. Tanner, British Columbia Ministry of Environment.

9. OECD (1985, page 65).

10. Id., page 66.

11. Id., page 66.

12. Id., page 67.

VI - EXISTING EFFLUENT CHARGE SCHEMES EXAMPLES AND CRITIQUES

INTRODUCTION

In this chapter we provide descriptions and evaluations for selected effluent charge schemes which we have identified in the economic literature. The evaluations are based on the criteria set forth in Chapter III and Appendix B.

SEWER SURCHARGES IN CANADA

Some municipalities apply a surcharge on the water bill to certain industrial users. Charges may apply to certain pollutants, to volumes of discharge or to extra strength emissions, such as BOD, phenols or TSS. These charges, were, in many cases, a response to an overburdened municipal sewage system. Charge revenues essentially assist in the financing of municipal sewage treatment and transfer some cost from domestic-commercial users to industrial users. Certain of these schemes are described in Demakeas (1974) and Sims (1977).

Evaluation

It has been shown by Sims (1979) that, in the case of the brewing industry, there is considerable abatement responsiveness to these pollution charges. The schemes are simple to operate and monitoring costs, for the pollutants chosen, are not onerous.

A weakness of some surcharge systems is that charges are based only on concentration threshold values. If charges are made only on the basis of concentration, or if the charge for volume is relatively small, a firm can dilute its wastes to obtain the requisite concentrations without reducing the actual loadings to the environment. This practice will add to the hydraulic load of the sewage system and could ultimately require unnecessary expansion of the plant.

FRANCE, WEST GERMANY, THE NETHERLANDS, HUNGARY, EAST GERMANY

An OECD (1980) report records the experience of emission and effluent schemes in European countries. Charge systems are in place for wastewater effluents in France, West Germany, the Netherlands, Hungary, and East Germany. The term pollution charge includes effluent charges for direct discharges into rivers and lakes and user charges for discharges into community sewer systems.

Evaluation

The water pollution charge schemes in place are primarily designed to generate revenue to finance collective treatment systems rather than to give polluters incentives to reduce emissions. Financial assistance to industrial pollution sources have also been implemented in each of these jurisdictions. Moreover, there have been few attempts to correlate the charge with pollution damages. Finally, in each jurisdiction, the charge schemes complement rather than replace traditional Command and Control policy instruments.

WEST GERMANY

The schemes referred to in the previous section have existed for some time in Germany under the auspices of the Genossenschaften, basin water associations established by special laws to collect revenues to cover association activities, such as operation, maintenance, and debt service of collective treatment facilities.

In addition to these longstanding systems, the Effluent Charge Law (ECL) was adopted in 1976, to take effect in 1981. It calls for states to levy charges on direct dischargers of specified effluents into public waters. Firms and households discharging into municipal sewers are not charged directly.

The rest of the notes in this section are taken from Brown and Johnson (1983).

Federally-created task forces have set technology-based minimum effluent standards which apply to individual industrial and municipal discharges across the country. Individual states can set higher minimums, as required, to achieve particular water quality goals.

Discharge permits are issued, specifying:

- Waste water quality requirements, maximum allowable waste water volumes per unit time and monitoring procedures.

- Effluent charge information: data necessary to compute the waste water discharge bill including subject pollutants and expected amounts of discharge.

The pollutants to which charges apply are: settleable solids, COD, cadmium, mercury and toxicity for fish. Effluents are converted to damage units.[1] The charge per damage unit is uniform across regions and polluters. Charges per damage unit have more than tripled since introduction in 1981.

The reference value for the computations of charges is the expected amount of pollution discharge stipulated in the effluent charge portion of the individual permit. The charge liability is lower under two circumstances. If the expected discharge level meets the federal minimum standards (or the state minimum, if higher), the charges are reduced by one-half. Second, if the actual discharge level is substantially below the expected level, the bill is based on the actual level of discharge.

When maximum levels of discharge, stipulated in the permits, are exceeded, polluters are penalized by having to pay more in the future, according to a formula.[2]

Revenues from the charges can be used by states for the costs of administering the ECL and for supporting pollution abatement activities such as research for innovations in technology; tertiary treatment plants and other investments which improve water quality beyond the minimum desired levels; lake rejuvenation; and large-scale, economical treatment plants which benefit regions.

One of the major difficulties identified in implementing the ECL involves the charging of indirect dischargers, i.e., those who discharge wastes into a municipal sewer system.[3] In West Germany, about 90% of all firms discharge into a sewer. Issues of allocative efficiency are involved, in terms of who abates, and whether polluters are presented with non-zero marginal prices and can take action based on their own marginal costs. Do municipalities increase their own treatment costs, or do they attempt to pass on the charges directly, through appropriate prices, to the indirect dischargers? The problem is that, in practice many municipalities in West Germany have such rudimentary sewer charge systems, that costs of waste treatment are buried in charges for raw water withdrawals. Finding a solution to a practical municipal pricing problem has important implications for the efficiency of the ECL for indirect discharges.

In order to address this problem, the government conducted a study of municipal charge systems in order to provide guidelines for municipalities to select an appropriate degree of complexity (charge rate differentiation) for their own effluent charge system.[4]

According to Brown and Johnson (1983, page 46), lessons learned from the short experience to date are that an effluent charge system is most likely to be politically viable and administratively attractive if:

1. It covers a small number of pollutants.
2. It is combined with permit systems.
3. The charges begin at some specified level and escalate during a transition period.
4. The charge levels result from a process involving the participation of interested parties includling those benefitted and harmed by waste dischargers.
5. Measures and levels of volumes and pollution concentrations are simplified.
6. Effluent charge revenues are made available for administration and abatement-related expenditures.
7. Hardship clauses are provided to protect dischargers or industrial sectors under exceptional circumstances (Section 6.1).
8. Care is taken to demonstrate how the effluent charge program actually can be implemented.

Evaluation

Some of the following comments are based on Johnson and Brown (1983).

Administrative Set up costs were substantial due to the need to establish a national set of effluent standards. In addition, the costs of administering the system at the local level required substantial staff increases for monitoring and evaluation. For two states, it was estimated that such costs would be from 10% to 30% of the anticipated charge revenues.[5]

Total charge revenues from the ECL are anticipated to be substantial, estimated at 350 million DM for 1981.[6]

The scheme is a combination of charges and standards. The efficiency criterion is not met by the scheme because each producer of a given product faces the same minimum standard and each must meet the same discharge standards, whether the cost of treatment is high or low. There are further questions relating to the achievement of allocative efficiency, depending on the way indirect dischargers are charged by municipalities.

The scheme as a whole has produced some incentive effects. There were significant increases in water treatment and related equipment investment during the announcement phase (1974-1979), so that by 1981, more than one-half of dischargers qualified for halving their charges. Ambient water quality also appears to have improved.[7]

However, it is believed that the charge rate per damage unit is too small and that charges, by themselves cannot achieve the desired water quality levels, or act as a great enough incentive for technological development.[8]

Since effluent charge revenues will more than cover the costs of administering the ECL, there will be an incentive for the states to increase enforcement activities and thus actual discharges will be closer to desired standards. In addition, requirements and monitoring procedures are stated more precisely than previously, so that data quality is increased, ambiguity is reduced, and the costs of enforcement are expected to be reduced.[9]

The scheme should also provide incentives for municipalities to adopt customer sewage pricing policies which offer incentives for the indirect dischargers to control waste production. However, assistance to municipalities was required in the design of such pricing policies.

Estimates have been made of the impact of the new scheme on industries and municipalities.[10] For industries, it has been estimated that charges and abatement costs were generally less than 2% of sales for the most serious polluters. Only in the pulp sector do charges loom large. It was felt that several of these plants are inefficient, and outmoded technologically, and their going out of business because of charges would in effect be only a slight advancement in their anticipated date of demise. For municipalities, it was estimated that the effluent charge and costs to meet minimum requirements would add about $6.00 (U.S.) per year per capita to the water and sewer costs.

ENGLAND AND WALES

Following the Water Act of 1973, the new Regional Water Authorities (RWA) became responsible for charging for industrial discharges to public sewers. Freeman (1977) provides a short description of the charge scheme in place for the Severn Trent Water Authority. Charges are applied to all dischargers in the region. The charges are set to recover all costs the authority incurs in receiving the effluent to the sewers, getting it to the treatment works and the treatment process itself. The pollutants of major concern are COD and TSS. The resulting charges are distributed approximately according to effluent volume (50%), biological treatment (25%) and sludge (25%).

Evaluation

The user-pay principle and the principle of efficiency are upheld, since in principle, each user pays the costs of "cleaning up" his discharges either to the Authority, or by his own abatement activities. From an administrative cost perspective, measurement of both discharge volumes and pollutant levels is required. Set up data consisted of very exhaustive studies into the breakdown of treatment costs.

There is an incentive not only to reduce effluents, but to reduce water intake as well, since 50% of the charge is directly related to intake. The scheme does not take into consideration the many other industrial pollutants which are likely being discharged.

SUMMARY

The following important points may be summarized from the foregoing:

- In some schemes, polluters are charged on the basis of the strength and volumes of their discharges.
- Effluent charges do have incentive effects on polluters with respect to the reduction of pollutant emissions.
- Most schemes have had revenue objectives with regard to recovering the costs of the waste treatment in collective facilities, or in recovering the costs of water quality management activities.

- Allocative efficiency issues arise in a scheme in which municipalities are treated as the direct dischargers who are subject to charges. The efficiency of the scheme depends, to some extent, on the ways in which the municipalities charge these indirect dischargers for sewer services. The redesign of some municipal sewage charge schemes was required in West Germany.

NOTES FOR CHAPTER VI

1. A damage unit for a pollutant is a specified amount of discharge. Brown and Johnson (1983) do not explain how these are developed. A table of damage unit conversions is provided in an Appendix of the Effluent Charge Law.

2. Brown and Johnson (1983, Note 39).

3. Ibid., pages 32.

4. Ibid., page 33.

5. Ibid., page 28.

6. Ibid., page 23.

7. Ibid., pages 20 and 21.

8. Ibid., page 20.

9. Ibid., page 26.

10. Ibid., page 13.

VII - DESIGN OF POSSIBLE WATER PRICING SCHEMES FOR ONTARIO

INTRODUCTION

In Chapter III, we presented an outline of the economic principles involved in pricing natural resources and, in particular, the pricing of raw water and of effluents. These principles can assist in the design and evaluation of pricing schemes for both raw water and effluents. In particular, these economic principles can provide guidance in setting charge rates, in assessing the data requirements for the implementation of various pricing schemes, and in assessing the potential impacts of the schemes on different sectors of society.

In the present chapter, we discuss three possible pricing schemes for raw water withdrawals in Ontario. For each, we present:

- a description of the scheme;
- the main objectives of the scheme;
- the relevant economic principles, particularly in regard to the determination of the charge rate;
- the data requirements for implementing the scheme;
- other implications;
- an evaluation of the scheme.

These schemes are intended to be applied to raw water withdrawal uses, rather than instream uses such as, for example, hydroelectric power generation.

Policy Objectives

In Chapter III, we listed the range of policy objectives which may be achieved by pricing schemes for both raw water and effluents. The three major objectives were:

- Revenue generation.
- Water resource management.
- Income redistribution.

A given scheme will address each of these objectives to a greater or lesser degree. The choice of possible pricing schemes will, therefore, depend to a great extent on the relative weights placed on these objectives.

In this chapter, we focus on three pricing schemes for raw water, each with different degrees of emphasis on each of the three main objectives.

Pricing Principle

The terms of reference for this study focus on pricing as an incentive to users to use less water, or to reduce the amount of effluents discharged. As discussed in Chapter III, such incentives will exist only if the user faces a non-zero positive price for the next (marginal) unit withdrawn, or discharged. Currently, users pay nothing for the withdrawal of raw water or for the use of waterbodies for waste disposal. For both raw water and effluents, the pricing schemes discussed in this report will require that each additional unit of withdrawals or discharge be paid for by users.

DESIGN CONSIDERATIONS

Each of the schemes described in this chapter involve a decision regarding the following factors.

Rate Structure

The term charge rate means the price per unit of water withdrawn, or of effluent discharged, as appropriate. For example, for raw water, the charge rate may be either uniform for all levels of withdrawal, or may vary. A typical charge rate structure, often found in the pricing of municipally provided waters to retail customers, is the declining block structure, in which the unit price of water declines with increased withdrawals. The range of withdrawals is divided into blocks within which the unit price is constant. Since there is a positive price for each unit of water used, there will always be an incentive to conserve. However, the strength of the incentive decreases as the volume of use increases. Alternatives include an increasing block rate structure (i.e., higher charge rates for higher volumes used) in which there is an increasingly greater incentive to conserve, and a uniform charge rate for all levels of use.

Charge for All Withdrawals or Above a Threshold Level

The charge rate may be applied to all withdrawals, or may apply only to those over a specified threshold level. The reason for pursuing the latter course may be to eliminate the administrative costs which may be attributable to many small users.

Single Charge Rate or Varying Charge Rates

The charge rate may vary according to a number of factors, including geographical location, user category or season. For example, the charge rate might be higher in an identified area of scarcity of supply, or during a seasonal period of lower flow rates in a particular water course. User categories may have different charge rates depending on the existence of economic rents, or other social and equity considerations.

EVALUATION

In this chapter we provide an evaluation of each scheme described. The comments are structured according to the evaluation criteria set forth in Appendix B of this report.

The criteria deal to a large extent with the potential effects of possible schemes. The economic principles elaborated in Chapter III are brought forward, where appropriate, to assist in the discussion of individual criteria.

POSSIBLE PRICING SCHEMES FOR RAW WATER

The three schemes described in this chapter are:

1. Revenue Based: A uniform charge rate for all users based on revenue targets.

2. Marginal Cost Based: Charge rates are designed to stimulate a specific level of reduced water use. The charge rate is based on users' cost functions including marginal costs for water-saving or recirculating technology.

3. Economic Rent Based: Differential charge rates based on differing levels of economic rents occurring in various industries or various geographical locations.

We discuss each of these in turn in the following three major sections.

REVENUE BASED WATER PRICING SCHEME: UNIFORM CHARGE RATE BASED ON REVENUE TARGETS

Objectives of This Charge Scheme

The main objectives of this scheme are:

- to achieve specified revenue targets;
- to have a water pricing scheme in place in anticipation of a greater future need for demand management tools in the face of potential scarcity of supply.

Description

The main features of the scheme are as follows:

- Charges are applied to all direct takings from surface and groundwater in excess of 50,000 litres per day (essentially permittees under the Ontario Permit to Take Water Program).
- The total amount of charges, per unit time, is equal to the quantity of water withdrawn per unit time, times the charge rate per unit of water.
- Quantity units are thousand cubic meters (10^3m^3) and the charge rate is expressed as cents per 10^3m^3 (¢/10^3m^3).
- Metering is required.
- Payments are due semi-annually or quarterly.

- Collection should be handled by the Capital Finance and Revenue Branch of the Ministry of the Environment which currently collects payments from municipalities.

- An annual inflation factor should be applied to the charge rate. Charge rates should be reviewed and adjusted every three to five years.

As described below, the charge rate is set so that the amount of total withdrawals, times the charge rate, results in the achievement of specified annual revenue targets. From this perspective, the revenue generation objective appears to take precedence over the other objectives.

Determination of the Charge Rate

The uniform charge rate is essentially determined by dividing the annual revenue target by estimated annual withdrawals. The revenue target may be determined by one of the following approaches:

- Recovery of annual (public) water quantity management costs, both current costs (for example, Permit to Take Water Program) and incremental costs resulting from the implementation and ongoing operation of this scheme.

- Recovery of estimated damages resulting from excessive withdrawals from some water courses.

- Generation of funds for research and development into water-saving technologies, or for public education regarding water conservation.

It might be desired to adjust the charge rate, as calculated above, for the fact that withdrawals may decrease from current levels due to the imposition of increased costs of water acquisition to the users. The extent of this charge rate adjustment will depend on the price elasticity of water withdrawals.

The choice of the revenue target, and hence, of the charge rate must be carefully considered in the first instance. Once a charge scheme is in operation, it may be relatively difficult to make significant changes to the level of the charge rate.

Data Requirements

The data requirements for this scheme are fairly straightforward. The main requirements are:

- Total annual water intake by all users.
- A statement of the desired revenue target, for example:
    - current water quantity management costs
    - estimated incremental charge scheme costs
    - other water related development costs.
- The price elasticity of water intake, and current water intake costs, by user class to assist in adjusting the charge rate to compensate for potentially decreased withdrawals, or to assist in estimating the impact of a given charge rate on water withdrawals.

For ongoing operation of the scheme, the primary data requirements are annual, or semi-annual quantities of water withdrawn, as determined from users' flow meters, both for existing users, and for new users.

Other Implications

The following points relate to the implementation of this scheme:

- The scheme applies to permit holders under the Ontario Permit to Take Water Program described in Chapter II. Records of permit holders are kept by MOE. As noted previously, the Water Taking Information System (WTIS) data base for permittees was up to date to about 1984. For current data, manual files would have to be consulted. However, certain additional direct takers, over 50,000 l/day, who do not have permits (for example, works installed before 1961) would also be liable for charges and require identification.

- The number of water taking permits in force as of March 31, 1984, was 6,208 of which 4,152 were for agricultural and other large watering uses.[1]

- There will be additional metering costs for some users. Many users currently have flow meters for water withdrawals.[2] These additional costs might be borne directly by the Government (covered by revenues from water charges), or borne by users, with a "holiday" from some part of the first year's water charges to compensate for these costs.

- Water meter readings could be taken by MOE personnel. Alternatively, the scheme may be operated by requiring users to submit meter readings on pre-designed forms with a certain frequency per year. In this case, additional staff may be required to audit/verify readings.

- As was shown in Exhibit II-2, thermoelectric power generation accounts for about 70% of water withdrawals in Ontario. Thus, if charges were applied to water withdrawals, Ontario Hydro would be liable for about 70% of annual water charges assessed under a uniform charge rate scheme.

- Manufacturing water withdrawals would account for about 22% of the total annual water charges. The four largest water-using industries in Ontario, in decreasing order of magnitude of withdrawals, are chemical industries, primary metal industries, paper and allied products, petroleum industries.[3] These four sectors would account for about 88% of the total annual manufacturing water charges.

- The scheme does not account for differences in actual consumption of water, as defined in Chapter II. In other words, although there are significant differences in the rates of consumption between users (Exhibit II-2), all users would still pay the same price per unit of water withdrawn.

- Municipalities are liable, as direct water takers, for the water charges related to their withdrawals. Users of municipally supplied water would pay the increased charges indirectly. This gives rise to the issue of the way in which municipalities would pass on the charges.

This is an important issue but is beyond the scope of this study to address.

- It should be noted that, for unmetered users of municipally supplied water who pay a flat rate water bill, the additional charge for raw water will provide no incentive to reduce water use.

- One of the major implications is that this scheme, although providing an incentive to conserve water withdrawals, does not take account of potential scarcity of water flows or social costs which may be imposed by water withdrawals. Such scarcity and social costs, as discussed in previous chapters, most often relate to water withdrawal conflicts in a particular watercourse, or at a particular time of year. In such cases, a uniform charge rate based on revenue targets will probably not reflect the full social opportunity cost of these withdrawals.

We have also argued in Chapter III that the existence of economic rents accruing to users of natural resources provides a basis for assessing a resource royalty, or resource tax. In the case of raw water, economic rents may accrue to some users in some industries. These rents might occur because of location near a plentiful source, or near an unusually pure source, requiring relatively lower treatment costs for the use.

These two principles lead us to the consideration of variations in the basic design, to allow for variations in the charge rate. The second and third charge schemes described below are operationally similar to the basic design, but allow, under certain circumstances, variations in charge rates. The ability to determine the appropriate charge rate in these cases depends on data availability.

Evaluation

The following discussion is based on the evaluation criteria for water and effluent charge schemes listed in Appendix B.

Incentive Effects

This scheme will provide a financial incentive to reduce water withdrawals since each additional unit of water is charged for (except in the case of some users of municipally supplied water).

However, if the charge rate is low, there could be concern that incentive effects may not be strong enough for some industrial users for whom total water costs are often less than 3% of total costs.[4] In some cases, the incremental water costs due to charges may appear insignificant, and may not provide a strong enough incentive for management to find ways of reducing such costs. It may be desirable for the Government to provide information to users concerning ways of reducing water intake.

Revenues to Government

The revenues generated by the scheme may be allocated to the various purposes identified in setting the revenue targets.

Costs of Administration

Additional costs to implement this scheme include the following:

- the major set-up costs are water meters which are required for some users;

- additional clerical support may be required to process and collect the water bills;

- meter reading/verification may be required.

Consistency with Current Programs

Although the imposition of a charge for raw water would be a new thrust in water management in Ontario, it is consistent with taxes and royalties levied on other natural resources in Ontario. This scheme could be considered complementary to the Permit to Take Water Program.

Adaptability/Flexibility

Allowing for an annual inflation factor will ensure that the total revenue from charges will maintain their relative purchasing power. The extent of reductions in withdrawals may not be maintained as economic growth occurs due to increasing size of water users, or new entrants. A schedule of increasing real rates, i.e., in constant dollar terms, would be required to maintain withdrawals at a constant level.

Local Economic Impacts

It may be possible to devote some of the charge revenues to financial assistance, if required, as long as the level of assistance is not related to the level of abatement. Otherwise, the incentive to abate might be reduced.

Allocative Efficiency or Cost Effectiveness

The primary policy objective of this scheme is revenue generation, rather than specific desired behaviour as regards water use reductions. However, some reductions in withdrawals may occur and these would be achieved by water users at the minimum cost to society.

Equity

The uniform charge rate has the appearance of being equitable since every user pays the same rate per unit of water. On the other hand, the level of total charges may affect some users more than others. For example, industrial users whose water acquisition costs account for a relatively larger proportion of their total factor input costs would be affected to a relatively greater extent by the imposition of additional charges than those users whose water costs are relatively small. These effects may be mitigated by allocating some of the revenues to financial assistance programs as noted above.

Users who have already invested in water-saving technologies may feel that the additional new charges are inequitable.

Technological Innovation

One of the most important attributes of a water charge scheme is likely its ability to stimulate the development and use of water-saving/recirculating technology.[5] Users will have an incentive to install such technology up to the point that the marginal cost of avoiding the use of the next unit of water just equals the charge rate. Over time, these incentives may result in the development of more effective and less costly water-saving technologies.

MARGINAL COST BASED WATER PRICING SCHEME: CHARGE RATE DESIGNED TO STIMULATE SPECIFIED REDUCTIONS IN WATER INTAKE

Objectives

The main objective of this scheme is to achieve a reduction in water use of a pre-determined amount, rather than a pre-determined level of revenues. This scheme would seem to be most applicable to an area of scarcity, that is, to a particular source of supply, or in a particular season of the year where conflicts between water withdrawal uses may be occurring, or in situations where conflicts between withdrawal and competing instream uses (e.g., recreation or biological life support needs) may be occurring.

It might also be desired to achieve specified province-wide reductions in water withdrawals. Although this may be done in principle, the practical difficulties with regard to data requirements, as described below, may make province-wide application unfeasible.

Description

- The scheme applies to direct takers over 50,000 l/day, as in the first scheme.

- This charge scheme could be considered as a complement to the revenue based scheme, described above. A different set of charge rates, as distinct from the uniform rate discussed above, would be applied to the affected users in the areas of scarce supply. Other users would still pay a revenue based rate.

- Other operational details of this scheme are the same as the uniform charge rate described above.

Determination of the Charge Rate

The basic economic principle invoked here is that when faced with a charge for raw water, a user will find ways to reduce water use, to the point at which the user's costs of avoiding the withdrawal of the next unit of water equal its price. This principle was discussed in Chapter III. This behaviour results in the minimization of total private water use costs (charges plus internal costs to users). The implication is that, with sufficient knowledge of users' internal costs of water-saving or recirculating technologies, we can predict their behaviour with respect to a given charge rate. We can also determine the charge rate which is required to achieve a given amount of water use reduction.

The determination of the charge rate applicable to a set of users on a given water course might include the following steps:

- Determination of the desired level of water use reduction.

- Collection of abatement cost data (capital and operating costs) of water-saving options available to the relevant group of water users.

- Using the cost data, assessing the extent of overall water use reduction expected to result from each of a range of charge rates by examining the expected (cost-minimizing) behaviour of each water user. This step will allow the identification of the charge rate which will achieve the desired level of reduction.

The determination of the charge rate which would achieve an overall specified provincial reduction in water use is clearly more complex. In principle, the steps and data requirements are similar to those just discussed, except they are required for all water users. It may be possible to treat all users of the same type as identical. That is, their marginal cost functions for water-saving equipment are identical. In essence, all users in the same group are aggregated and treated as one user.

Data Requirements

As discussed above, the data requirements for the set up of a marginal cost based scheme focussing on a particular water course include:

- The determination of the desired decrease in water intake by users on the water course. The determination of this level by MOE can take account of current intake levels, average flows by season and minimum flow requirements in respect of other non-withdrawal users such as:

    - life support for aquatic and other ecosystems affected by or dependent on the water course

    - other instream uses as depicted in Exhibit II-1, for example, recreation or navigation.

- Cost function data for water-saving technologies for each direct taker on the water course in question. These data are generally obtained only by special studies.

For a marginal cost based pricing scheme focusing on overall provincial intake reductions, data requirements include:

- The determination of the desired overall level of water intake reduction. This would be primarily a policy decision, since scarcity is only a concern in localized areas.

- Marginal capital and operating cost data estimates for each user category (as many as 10 to 15, based on the breakdown in Exhibit II-3). Such aggregated data, would only provide approximations for the purpose of simulating users' behaviour in response to given charge rates.

- Alternatively, estimates of total current water costs, both private costs and payments to public utilities, for individual user groups could be obtained. When combined with price elasticities for intake water (from the literature), an estimate can be made of the change in total water cost, i.e., the additional raw water charges, which are required to stimulate a desired reduction in use. The methodology and use of these kinds of data are illustrated in Chapter IX.

Extensive surveys of water users, regarding both usage patterns and costs incurred, are required to gather industry-wide/province-wide data covering most users. The only source of such data on a comprehensive and province-wide basis is Environment Canada. Industrial Water Use Surveys for industrial, mining and thermal power generation have been carried out for 1972, 1976 and 1981. The results for 1981 are reported in Tate and Scharf (1985a and 1985b) and have been used in this study, both in Chapter II, and in Chapter IX.

Estimates of price elasticities for water intake must be gathered from the literature. Very little work has been done in Canada with regard to industrial uses. Renzetti (1986) estimates price elasticities for industrial and mining intake, using data from the 1981 Industrial Water Use Survey. Some earlier papers in Canada have estimated price elasticities for residential/commercial water from municipal sources.[6]

Other Implications

As was noted in Chapter II, scarcity of flows and withdrawal conflicts in Ontario in recent years have often been associated with withdrawals from some water courses for irrigation uses. The imposition of marginal cost based schemes may therefore often apply to agricultural users. To the extent that the cost based charge rate is higher than the uniform revenue based charge rate, the scheme might appear to single out farmers.

Evaluation

Many of the comments on this scheme which might be made with regard to the evaluation criteria are similar to the basic scheme which might be made described above. However, different comments may be made about the following criteria:

Incentives

The implementation of a marginal cost based scheme will likely result in differential charge rates, with higher rate applying to the areas of scarcity of supply. In some cases, these differential rates may provide an incentive for some existing users to relocate to cheaper supplies, or for new firms to locate near cheaper supplies. The feasibility of relocation would depend on the magnitude of relocation costs in relation to raw water costs, and the reasons for the original location decision (for example, proximity to supplies of other natural resources). Many firms would find it infeasible to relocate.

The achievement of the objective of reduced intake must, however, be balanced against the potentially decreased level of economic activity in the area.

Revenues to Government

Revenue from this scheme could be used in a number of ways, including:

- compensation for damages from excessive withdrawals;
- financial assistance to particular water users with lesser ability to pay the water charges, as long as the incentive to reduce withdrawals is not affected;
- development of water-saving technologies.

Costs of Administration

As noted above, the set-up costs of this scheme, primarily for data requirements, are much greater than in the revenue based scheme. Other incremental ongoing costs should be about the same.

Local Economic Impacts

This scheme may involve higher charge rates for users in some locations than in a uniform revenue based scheme. Total water charges may not be high enough to affect the location decisions of water users. However, this possibility should be recognized in the design of this scheme. Financial assistance programs may be considered, if appropriate, in these cases.

Allocative Efficiency or Cost Effectiveness

The primary policy objective of this scheme is to reduce water intake, either in a particular water course or overall for Ontario.

As has been discussed in the Economic Principles in Chapter III, individual cost-minimizing behaviour (making choices between paying charges and investing in water-saving technologies) will result in the attainment of the desired reductions at the least overall social cost.

Equity

The imposition of a scheme with the objective of reducing withdrawals in certain water courses would likely result in charge rates higher than in the revenue based scheme described above. In this case, users would be paying relatively greater charges than similar users on other water courses. This might appear inequitable to the user, but on the other hand, the user is paying a price which closely relates to the costs imposed on other sectors of society by his water use.

ECONOMIC RENT BASED PRICING SCHEME:
CHARGE RATE BASED ON ECONOMIC RENTS

Objectives

The objective of this scheme is the generation of revenues by charging prices for water withdrawals that reflect economic rents earned by some users due to their access to water at "lower cost" than is available to some other users. This scheme, therefore, also has an income redistribution objective, but does not include, as a specific objective, the reduction of levels of water withdrawal.

Description of the Scheme

- The operational aspects of the scheme are similar to those described above for the first two schemes. The major difference is the determination of the charge rates.
- It can be considered a complement to the revenue based scheme in which some users would pay higher charges based on the existence of economic rents.

Economic Principles

The concepts of economic rent are applicable to users who use water as in input to the production of a final product for sale to consumers, primarily manufacturing/industrial/mining uses and utilities. In simple terms, economic rents are earned when revenues exceed costs, including a normal return on investment. We have discussed the concept of economic rent in more detail in Chapter III.

Economic rents may be earned by some producers for many reasons, for example:

- the selling prices of final products may be determined on world markets and be relatively high in some periods; (This could apply to all producers in a particular industry.)
- some inputs may be obtained at a relatively lower cost for some producers.

With respect to natural resource use, we have argued that the existence of economic rents provides a basis for the pricing of the raw resource, or the taxation of profits derived from its exploitation.

In the case of the use of raw water, economic rents may be earned by some producers in a particular industry if the characteristics of their water supply are such that their total water costs per unit are less than for their competitors. The relevant attributes of water are the available flow and its quality.

Considering available flow, a producer situated on a watercourse with sufficient flows that there are no withdrawal use conflicts may employ "once through" water use technologies. On the other hand, another producer of the same final product may be situated on a much smaller watercourse and find it necessary to use recirculation technologies. In this latter case the per-unit cost of water is higher than in the former case.

A similar situation could be envisaged in which a certain quality of water is required. At one location, water may require minimal pre-treatment while at another location, the water may require substantial pre-treatment. Thus, in the latter case, the unit costs of water are higher.

In both the above cases, economic rents may be earned by the "lower cost of water" producers. These apparent rents may, however, be offset by other production costs linked to the lower cost water location. For example, higher quality water may be farther away from the final product market, thus increasing transportation costs and thus, at least partially, eliminating the advantage of the low cost water.

On the other hand, it is questionable whether most such economic rents as discussed above exist now, or would have existed for any length of time.

They may have been "competed away". For example, if "low cost" water had existed, producers would have made appropriate location adjustments. In this case, rents would disappear because most users would face the same costs. Of course, there may be very localized examples, such as in the Hemlo mining example discussed in Chapter II, in which moving is impossible, and thus the rents may still exist.

We have discussed two potential ways in which economic rents might accrue to industrial water users:[7]

- location on watercourses with large flows
- location on watercourses with high-quality water.

These could lead to a pricing scheme in which there is a basic charge rate, as in the uniform revenue based scheme described above, with the imposition of higher charges for some watercourses.

Data Requirements and the Determination of the Charge Rate

The determination of differential rates based on economic rents earned because of lower cost water would require first, the documentation of the existence of economic rents. This would require studies of each major industry group, or alternatively, only the large water-using industries. Company-by-company surveys of water usage and related costs would have to be undertaken. Relationships of average water cost per unit and location would have to be developed. Only that portion of all economic rents attributable to water must be identified and more expensive offsetting production/marketing costs must also be identified. These types of studies are fraught with data availability problems as well as conceptual difficulties. For example, the concept of a "normal" rate of return to the shareholders/owners must be addressed.

These issues would be the subject of close examination by water users who may be affected by this scheme. It may be that these conceptual and empirical difficulties make this scheme impractical.

It may be determined that certain watercourses are the sources of economic rents to users located on them. It may also be determined that certain industries are the consistent recipients of economic rents. In these cases, estimates of the economic rent per unit of water intake would provide guidance in the determination of the appropriate charge rate.

There is a further, perhaps more serious problem in basing the charge rate on estimates of economic rent. Economic rents may change substantially over time (for example, they may be competed away). This causes a dynamic problem in rate setting. Water users would find planning more difficult with the knowledge that the rate may change substantially or in an unpredictable manner.

Evaluation

We address only those criteria for which our comments are different for this scheme.

Costs of Administration

- Setup costs may be relatively high in terms of data acquisition.
- Most ongoing operational costs are similar to the revenue based charge scheme. However, in line with the above discussion, ongoing studies would likely be required in order to update the estimates of economic rents.

Consistency With Current Programs

Recovering economic rents is consistent with other natural resource revenue programs.

Equity

Some users/industries will likely be subject to higher water charge rates than others under this scheme. As well, a problem in marketing the scheme and achieving consensus among water users thus emerges: water users would likely have to agree that economic rents of the magnitude identified do, in fact, exist, and that the charge rates are justified.

The primary impact of this scheme is income redistribution through the transfer of the charges from the producer to the Crown. It may or may not be possible to pass on the charges to the final consumers of the goods produced. If they are passed on, then consumers will pay more per unit and perhaps buy less, depending on the price elasticity of demand for the final product.

NOTES FOR CHAPTER VII

1. WTIS summary document supplied by Mr. D. Vallery, Ontario Ministry of the Environment.

2. Personal communication, Mr. D. Vallery (see 1 above).

3. Derived from Exhibit II-3.

4. Renzetti (1986, page i) indicates that, in British Columbia, the share of water costs to total costs for manufacturing ranges from 0.5 percent for metal fabricating industries to 3 percent for wood products industries.

5. A parallel point was made by Russell (1979, page 178) with respect to pollution abatement technology. It seems equally valid for water use reduction technology.

6. See for example Grima (1972), Sewell and Roueche (1974), Macerollo and Ingram (1981), Sigurdson (1982).

7. The generation of electrical energy is an example of the production of a final product which may be accomplished by very different means: hydroelectric and thermoelectric generation. As noted previously in this report, the economic rents exist for the use of water in the generation of hydroelectricity because it is much cheaper than the alternative, thermoelectric generation, which uses either fossil or nuclear fuels and which does not use water as the "fuel".

VIII - DESIGN OF POSSIBLE EFFLUENT CHARGE SCHEMES FOR ONTARIO

INTRODUCTION

In the present chapter we discuss three possible effluent charge schemes for discharges of wastewater in Ontario.

Policy Objectives

As described in Chapter III, the three major policy objectives are:

- Revenue generation
- Water resource management
- Income redistribution.

A given scheme will involve each of these objectives to a greater or lesser degree. The design of possible effluent charge schemes will depend to a great extent on the relative weights placed on these objectives.

Pricing Principle

The possible effluent pricing charge schemes discussed in this report will have as a characteristic that each additional unit of discharge be paid for by users.

The effluent charge schemes described in this report apply to pollutant loadings (in terms of kilograms per unit time emitted to receiving waters) rather than effluent volumes (cubic meters of discharge per unit time). This enables the targeting both of specific pollutants and the actual amounts of them discharged to the environment.

Effluents can contain one or more pollutants each of which may cause environmental damages. In addition, the strength of concentration can vary from time to time so that a given volume of effluent may be more or less damaging. For these reasons, it is more appropriate to target for charges the actual amount of pollutant entering the environment, rather than the total volume of effluent.

DESIGN CONSIDERATIONS

Possible effluent charge schemes will involve decisions on factors similar to those described in Chapter VII for raw water pricing:

- Rate structure.
- Charge for all emissions, or those above a threshold.
- Single charge rate or varying charge rate.

EVALUATION

As for the raw water pricing schemes, we provide an evaluation of the effluent charge schemes structured according to the criteria in Appendix B.

It should be noted that Peat, Marwick and Partners (1983, Pages VII-12 to VII-17) contained a complete evaluation of effluent charge schemes, using essentially the same criteria as in Appendix B. In addition, various practical design considerations were discussed in Appendix D, pages D-3 to D-8. Although the illustrations in that study most often related to airborne sulphur dioxide emissions, the basic principles elaborated are equally relevant to this study.

POSSIBLE EFFLUENT CHARGE SCHEMES

In this chapter, we discuss three possible effluent charge schemes, which are in many ways parallel to the three raw water charge schemes described in Chapter VII:

1. Revenue Based: A uniform charge rate for all discharges of a given pollutant, based on revenue targets.

2. Marginal Cost Based: Charge rates are designed to stimulate a specific level of abatement for each pollutant. Such charge rates are based on polluters' abatement cost functions.

3. Economic Rent Based: Charge rates reflecting economic rents earned by some industries, or in some locations due to higher levels of assimilative capacity of receiving waters.

We discuss each of these in turn in the following three main sections.

REVENUE BASED EFFLUENT CHARGE SCHEME: UNIFORM CHARGE RATES BASED ON REVENUE TARGETS

Objectives

The main objectives of this scheme are:

- To achieve specified revenue targets.

- To provide an incentive to reduce pollutant emissions and thus make more efficient use of Ontario's water resources.

As described below, the charge rate is set so that the amount of total loadings, times the charge rate, results in the achievement of the specified revenue targets.

Description

The main features of the scheme are as follows:

- For a given pollutant, charges are applied to all direct discharges to receiving waters for those dischargers who exceed a certain threshold level, perhaps only those who are recorded in the Industrial Monitoring Information System (IMIS).
- The amount of charges, per unit time, is equal to the quantity of pollutant loadings times the charge rate.
- The units for quantity of loadings are tonnes per year (tonnes/yr) and for the charge rate are dollars per tonne ($/tonne).
- A determination of the annual loadings of each pollutant in the scheme is required. It must be acceptable to both the Ministry and the polluter as representative of actual loadings.
- Payments are due semi-annually, or quarterly.
- Collection should be handled by the MOE.
- An annual inflation factor should be applied to the charge rate.

Determination of the Charge Rate

The uniform charge rate is essentially determined by dividing the annual revenue target by annual loadings. The revenue target may be based on one of the following approaches:

- Recovery of annual (public) water quality management costs, including current programs, and any incremental costs resulting from the implementation of this scheme.
- Recovery of other social costs, such as estimated damages resulting from the pollutant discharges.
- Generation of funds for research and development into new abatement technology.

Allowance must also be made, in the determination of the charge rate, for the fact that the effluent charge will be an incentive for polluters to reduce loadings from current levels. The extent of the compensating increase in price, over the initially computed value, to achieve the same target revenues will depend on the price elasticity of discharged loadings.

The choice of the revenue target, and hence of the charge rate, should be carefully considered in the first instance. It may be relatively difficult to make significant changes to the charge rate, once a scheme has been implemented.

Data Requirements

For set-up, the main requirements for this scheme are:

- Total annual loadings by all dischargers for each pollutant under consideration.

- A statement of the desired annual revenue target.

- The price elasticity of loadings.

For ongoing operation of the scheme, the main data requirements are measurements of actual loadings.

Other Implications

- Charging only those who discharge over a certain threshold limit has the administrative cost advantage of eliminating many small polluters from consideration.

  For industrial polluters, this may perhaps be accomplished by the application of the scheme only to those polluters recorded in IMIS. Focusing on IMIS recognizes that these polluters have already been judged by the Ministry as significant polluters. IMIS now contains data on approximately 150 industrial establishments.

  For municipal discharges from sewage treatment facilities, an examination of UMIS may be undertaken to select the large emitters over a certain threshold. This would likely substantially reduce the number of eligible municipalities from the approximately 400 current waste treatment facilities.

- Revenues may be collected by a new unit in MOE, or may be handled by the Capital Finance and Revenue Branch.

The latter seems reasonable, as this branch is now dealing with municipalities. The number of extra accounts may not be large.

- As noted above, a reliable and mutually acceptable monitoring mechanism for the measurement of discharge loadings must be identified. Currently, the loadings data in IMIS and UMIS are provided by the polluters, with some audit by MOE.[1] There appear to be three main approaches:
  - MOE uses loading data as currently provided and audited. This is the least cost monitoring option. It should be noted that these are the basic data available for use in the Ministry's current programs for pollution control.
  - MOE conducts its own full monitoring of all subject polluters. This is the maximum cost monitoring option.
  - A reasonable compromise between these two polar opposites is a system in which MOE accepts the data as currently provided, but institutes a systematic audit or verification program to check that loadings are as stated, within a reasonable degree of error.

The last option is likely the least cost way to achieve a satisfactory monitoring system. It would likely require incremental resources in personnel, travel, laboratory and equipment costs to carry out a systematic verification program. The frequency of verification would depend on the degree of statistical error to be tolerated in loadings measurements, and on the degree of fluctation of loadings over time at each given source.

- The foregoing discussion has dealt conceptually with the operation of a scheme which would assess charges for only one pollutant. However, the province may want to charge for several pollutants.[2] In this case, the revenue-raising objective may be stated as:

    - specified target revenues from charges on each individual pollutant

    - specified total revenues from charges on all pollutants.

The first option implies several similar calculations, each leading to a charge rate specific to a given pollutant. In general these charge rates would be different, depending on the relationships between target revenues and loadings. Different charge rates by pollutant can be justified on the principle that the social costs or damages related to pollutant loadings may differ from pollutant to pollutant.

Alternatively, in the second option, it may be desirable to identify one overall level of target revenues, and divide by the total of weighted loadings for each pollutant under consideration. These weights could be designed to reflect our best knowledge concerning the relative damages per unit of each pollutant. This would result in higher or lower charge rates per unit of loading, based on the relative unit damage estimates. Of course, equal weights (of unity) may be assigned, leading to one uniform charge rate for all pollutants.

- In this charge scheme, municipalities are liable for the effluent charges related to their discharges. Users of municipal sewage treatment facilities would pay the additional charges indirectly. This gives rise to the issue of the way in which the municipalities, as intermediaries, would pass on the charges to their customers. Clearly, the municipality could not pass on to individual polluters charges related to specific pollutants unless these polluters were being monitored separately. It appears that at the current time, some municipalities do not know, with accuracy, what pollutants are being discharged into the sewer system, and who the polluters are.[3] It should be noted that "the vast majority of Ontario's 11,000 industrial plants discharge into a municipal sewer" (Ontario MOE (1986, page 1)). Thus, the provision of a price incentive to many individual dischargers into sewer systems would require increased monitoring activities by municipalities.

  If the municipality simply "spreads" the charges over all users, and undertakes no abatement activity on its own, it is possible that the incentive effect will be lost, and no abatement by individual polluters will occur.

- On the other hand, the pricing incentive, although not the main objective of this uniform scheme, may act on the municipality as the polluter. In fact, economies of scale, with regard to pollution abatement equipment, may make the municipality a "low cost" abater so that the price incentive might be relatively stronger than for the many smaller polluters connected to the sewer system, and thus, a greater degree of aggregate abatement might be achieved than if polluters faced charges individually.

- One of the most important implications of this scheme is that no account is taken of the actual level of social cost or damages which might result in some regions from the discharge of pollutants. We have argued in Chapter III that the true cost of pollution discharges is their social opportunity costs. It is clear that, for a given pollutant, these costs may vary from place to place, depending on factors such as the assimilative capacity of the receiving waters, and costs or damages imposed on other competing users of the same waters. In addition, economic rents may accrue to some users in some industries.

  These points lead us to the consideration, below, of variations in the basic uniform charge rate design to allow for higher charge rates in some areas where social costs or damages are occurring, or economic rents exist.

Evaluation

The following discussion is based on the evaluation criteria for water and effluent charge schemes listed in Appendix B.

Incentive Effects

Although the scheme is based on the generation of specified revenues, it should also provide a financial incentive to the polluters who are charged to reduce loadings, since each additional unit of loadings is paid for. The amount of abatement depends on the level of the charge and the private costs of abatement faced by polluters. As explained in Chapter III, abatement will take place to the point where the marginal cost of abating the next unit equals the charge rate.

Revenues to Government

The revenues may be allocated to the various purposes identified in setting the revenue targets.

Costs of Administration

There are additional costs to implement this scheme:

- Set up costs include identification of the subject pollutants and polluters, and the design of a mutually agreed upon monitoring system for discharge loadings.

- Additional ongoing costs include clerical support for processing and collecting pollution bills, possible additional staff for monitoring and laboratory costs.

Consistency With Current Programs

No changes would be anticipated with respect to current regulatory programs. The charge scheme would constitute a new program complementary to existing pollution control programs.

Adaptability/Flexibility

A fixed charge will not maintain the same real level of revenues under conditions of inflation. This may be accomplished, however, with an annual inflation factor.

In addition, a fixed charge will not maintain the same level of discharge reductions under conditions of growth in the subject industries (due to increased output, or new entrants). A schedule of increasing real rates, i.e., in constant dollar terms, would be required to accomplish this. However, this factor may not be as important, if revenue generation is the dominant objective.

Local Economic Impacts

It may be possible to devote some of the charge revenues to financial assistance, if required, as long as the level of assistance is not related to the level of abatement. Otherwise, the incentive to abate might be reduced.

Allocative Efficiency or Cost Effectiveness

The main objective of the scheme is revenue generation, rather than to induce certain abatement behaviour. However, those reductions which do occur will be achieved by polluters at minimum cost to society.

Equity

All identified subject polluters of a given pollutant pay charges at the same charge rate regardless of past abatement investments. Some polluters who have previously made such investments may feel that they have done all they can in regard to abatement, and that it is unfair if they still have to pay charges.

All polluters are also subject to the charges regardless of their current ability to pay. This may be perceived as inequitable by some polluters. These conditions may be mitigated, if appropriate, by allocating some of the revenues to financial assistance programs.

Technological Innovation

As is noted in Chapter VII, one of the advantages of charge schemes is that, over time, there is an incentive to develop and install more effective and less costly abatement technologies.

MARGINAL COST BASED EFFLUENT CHARGE SCHEME: CHARGE RATES DESIGNED TO STIMULATE SPECIFIED POLLUTION ABATEMENT

Objectives

The main objective of this scheme is to achieve a specified reduction in emissions based on an emissions objective for selected pollutants. It may be desired to reduce pollutant loadings in a particular water course where damages are occurring or the assimilative capacity of the receiving waters is being depleted by excessive discharges.

Description

- The description of the scheme is similar to the revenue based scheme.

  The main difference involves the determination of the charge rates. Charge rates are based on the private abatement cost functions of polluters, as described below.

This scheme would be a complement to the revenue based scheme. Subject polluters would face a different set of charge rates, as distinct from the uniform revenue based rate.

Determination of the Charge Rate

As discussed in Chapter III, the imposition of a charge on emissions will induce polluters to invest in pollution equipment or strategies to the extent that the cost of abating the next unit of pollution just equals the charge rate for that unit. This behaviour results in the minimization of total costs (charges plus internal abatement costs) for each polluter. Therefore, with sufficient knowledge of polluters' abatement costs, we can predict their abatement behaviour for a given charge rate. Further, we can also determine the charge rate which is required to achieve a specified level of abatement.

The determination of the charge rate applicable to a group of polluters of a given pollutant might include the following steps:

- Identification of the subject polluters:
    - in a given watercourse
    - in the Province.
- Collection of data (capital and operating costs) for the appropriate abatement technologies for each polluter.

    If the number of polluters is large, it may be possible to separate them into homogeneous (industry) groups in which abatement costs are assumed to be similar. We could then treat each group, in effect, as one polluter.

- Using the cost data, assessing the extent of overall abatement resulting from each of a range of charge rates by examining the expected (cost-minimizing) behaviour of each polluter. This step would allow the identification of the charge rate which will achieve the desired level of abatement.

Data Requirements

The data required to set up an marginal abatement cost based charge scheme focusing on a particular watercourse include:

- Determination by MOE of the desired decrease in pollutant loadings, taking into account such factors as:
  - relationships between loadings and ambient water quality levels
  - damages from the pollutant sustained by other water users.
- Abatement cost function data for abatement technologies and strategies available to each polluter on the watercourse. These data are usually obtained only by special studies.

Other Implications

- Although we have discussed in Chapter III that the measurement of damages from pollution is not currently sophisticated enough for use in the determination of charge rates, it is still possible to bring to bear all existing knowledge. This may be done in the setting of the emissions objectives, that is, the desired levels of abatement.

- If several pollutants are subject to charges, it is possible to determine an appropriate charge rate for each, with reference to abatement cost functions. In cases where an individual source is the emitter of more than one of the subject pollutants, there may be some difficulty in separating out individual abatement cost functions.

- Ambient water quality is sometimes a more important measure of the impacts of pollution in a particular watercourse than pollutant loadings. The linkages between point source loadings and ambient quality are difficult to model. The precise location of a point source on a given watercourse is an important determinent of its impact on water quality. Many commentors have concluded that, ideally, an effluent charge scheme would have to use individual charge rates to induce a specified improvement in ambient quality.[4] This is generally impractical because of data limitations regarding the relationship between loadings and ambient quality objectives. In addition, it would be difficult to avoid a perception of inequity when polluters on the same watercourse face different charges.

Evaluation

The main points of difference between a marginal cost based effluent charge scheme, and a revenue based scheme, relate to the concepts of effectiveness, efficiency and equity. Other differences involve the disposition of revenues and the costs of administration.

Incentive Effects

If the charge rate has been developed from the appropriate abatement cost data, the scheme will provide an economic incentive to abate to the desired levels.

Revenues to Government

Revenues could be used in a number of ways, including:

- Compensation to the victims of pollution.
- Financial assistance to particular polluters with lesser ability to pay the charges, as long as the incentive to abate is not affected.
- Development of more effective, less costly abatement technologies.

Costs of Administration

The extra costs for this marginal cost based scheme, over the costs for a revenue based scheme, relate mostly to the generation of abatement cost data. Special studies are usually required.

Local Economic Impacts

It is possible that the achievement of a particular emissions objective on a given watercourse may require substantial abatement from some polluters. Some polluters may also consider changing location. In these cases, a financial assistance scheme may be considered, as long as abatement incentives are not affected.

Allocative Efficiency or Cost Effectiveness

The prime objective of this scheme is to reduce pollutant loadings, either in a particular watercourse, or overall for Ontario. As has been discussed in Chapter III, individual cost-minimizing behaviour will result in the attainment of the desired abatement by the subject polluters at the least over all cost to society.

Equity

Similar comments may be made as for the revenue based scheme. Issues of equity may, however, be perceived as more important to polluters if the charge rates are higher for some pollutants, or on some watercourses, than they would be in a revenue based scheme.

ECONOMIC RENT BASED EFFLUENT CHARGE SCHEME: CHARGE RATE BASED ON ECONOMIC RENTS

Objective

The objective of this scheme is the generation of revenues by charging prices for emissions that reflect economic rents earned by some polluters due to the availability to them of "lower cost" assimilative capacity. The scheme therefore has revenue and income redistribution objectives. It does not have a specific abatement objective.

Description

The operational aspects of the scheme are similar to those described above for the other effluent charge schemes. The major difference is in the determination of the charge rates. This scheme is complementary to the revenue based scheme. Users earning economic rents would pay rent based charges, in addition to any revenue based charges.

Economic Principles

We have used "assimilative capacity" to describe the effluent disposal and transport functions of water. Economic rents may exist for some producers when the assimilative characteristics of the receiving waters are such that their total discharge costs are less than for other producers. The existence of economic rents provides a basis for pricing a natural resource or taxing profits from its use.

As in the discussion of economic rents with regard to raw water use, both available flow and quality levels may again play a role. For example, a producer discharging into a relatively clean watercourse, or one with large flows, may not have to invest in as much wastewater treatment as a producer discharging into waters which are already at or close to their assimilative capacity.

In these cases, the water may be considered to be of lower cost to the producer, so that economic rents may exist. These apparent rents may, however, be offset by other production costs associated with the lower cost location. It may also be likely that such rents, if they have existed at some points in time, may have been competed away.

These considerations could lead to an effluent charge scheme in which higher charge rates are applied to polluters on some waterways.

Data Requirements And The Determination Of The Charge Rate

Special studies would be required to document the existence of economic rents for some producers or industries on some waterways. As in the case of the raw water pricing scheme based on rents, company by company surveys of wastewater discharges and associated costs would have to be carried out. Similar difficulties in isolating economic rents associated with wastewater discharge would be encountered as described in Chapter VII for the case of the raw water pricing scheme. These difficulties may lead to the conclusion that an economic rent based effluent charge scheme is impractical.

If economic rents can be identified and satisfactorily estimated, then the charge rate may be related to the average rent per year per unit loadings.

However, if economic rents change over time, a dynamic problem in rate setting will occur.

Evaluation

We address selected criteria in this section.

Costs of Administration

In comparison to the revenue based effluent charge scheme, substantial setup costs may be incurred with respect to studies of the determination of the existence and magnitude of economic rents due to "low cost" receiving waters. The process of achieving support by polluters for potentially varying charge rates may be more costly than either of the first two schemes.

Consistency With Current Programs

The recovery of economic rents is consistent with other natural resource revenue generating programs.

Equity

Some industries or individual polluters may pay higher charge rates than others, depending perhaps on the watercourse. This may give rise to problems in achieving consensus on the existence of economic rents and the justification for using them as a basis for the charge rate.

The main impact of the scheme is income redistribution through the transfer of the charges from the producer to the Crown. It may or not be possible to pass on the charges to the final consumers of the goods produced. If they are passed on, then consumers will pay more for the goods, and perhaps buy less, depending on the price elasticity of demand for the final product.

NOTES FOR CHAPTER VIII

1. Personal communication, Mr. Walter Suboch, Ministry of the Environment.

2. See Chapter II for a discussion of the criteria for the selection of pollutants for a charge shceme.

3. York (1986) discusses the problem of industrial pollutant discharges to municipal sewer systems.

4. See, for example, Russell (1979).

IX - ILLUSTRATION OF PRICING SCHEMES IN ONTARIO

INTRODUCTION

In this chapter, we use available data to assess the potential impacts of the water pricing and effluent charge schemes discussed in Chapters VII and VIII, respectively. We are able to make sample computations for both water pricing and effluent charge revenue based schemes. We apply the calculation methodologies to Ontario as a whole and to a selected case study area involving water users and waste dischargers in the Thunder Bay area. Due to data limitations, we show sample calculations for a marginal cost based effluent charge scheme only for the case study area. There are no data available which permit the illustration of economic rent based schemes. These would require water use and water costs breakdowns for industries by watercourse. Such detailed data apparently have not been collected in Ontario.

The range of impacts which are illustrated include:

- Charge rates which will achieve given target revenues.
- The distribution of the total charges (revenues) by user group, and individual user, where appropriate.
- Estimates of the incentive effects of the schemes.
- Estimates of administration costs:

Thunder Bay Case Study

A case study for the Thunder Bay area was suggested by the Ministry of the Environment. The Thunder Bay "area" for the purposes of this case study includes major water users and dischargers in the City of Thunder Bay and on the Kaministiquia River which empties into the Thunder Bay Harbour via the Mission River. Issues of water resource management in the area have been characterized as focusing on quality, rather than on availability of supply.[1] Data have been gathered both from the IMIS and UMIS data bases, and by personnel in the Northwestern Region of MOE.

Data Limitations and Qualifications

The calculations shown in this chapter are intended only as illustrations of the principles discussed in previous chapters. Certain limitations of the data should be kept in mind when assessing the results of the calculations. In particular:

- We show the methodology for adjusting the calculated charge rates for revenue based schemes for the effects of price elasticities of demand. It requires both estimates of the elasticities and the current costs of water acquisition to users. We note, in the following text, various limitations in the data at hand for this study.

- In the Thunder Bay case study, we show the methodology for assessing the impacts on specific polluters of a marginal cost based effluent charge scheme. As described in the text, due to deficiencies in the data, these calculations should serve only as an illustration of the methodology, rather than as a simulation of available abatement strategies and behaviour when facing effluent charges.

EXHIBIT IX-1

TOTAL DIRECT WATER WITHDRAWALS ONTARIO 1981
SELF SUPPLIED[1]
(Million Cubic Meters - MCM)

User Category	Water Withdrawal (MCM)
. Agriculture	148
. Minerals Extraction	114
. Industrial/Manufacturing:	
- Food and Beverages	66
- Rubber, Plastics, Textiles	90
- Wood Industries	4
- Paper and Allied Products	595
- Primary Metals	1,103
- Metal Fabricating	4
- Transportation Equipment	56
- Non-metallic Minerals	44
- Petroleum Industries	326
- Chemical and Chemical Products	1,860
- Other Industries	153
Subtotal	4,301
. Thermoelectric Power Generation	14,925
. Municipal:	
- Ministry Operated[3]	253
- Municipally Operated[3]	1,489
Subtotal	1,742[2]
Total, all users[4]	21,230

Notes

1. Sources of self-supplied water withdrawals:
    - Agriculture: Exhibit II-3, assuming all withdrawals are self-supplied.
    - Minerals extraction and thermal power: Tate and Scharf (1985b, Vol. II)
    - Industrial/Manufacturing: Tate and Scharf (1985b, Vol. I).

   The values shown here for minerals, industrial/manufacturing and thermoelectric are the volumes shown in Exhibit II-3, less supplies from public sources, as shown in Exhibit II-3.

2. This value is total direct intake by municipalities, including water used by industries. It is calculated as 1450 (Exhibit II-2) plus water taken by minerals/manufacturing/thermoelectric users from public sources (see Note 1).

3. The split between Ministry operated, and municipally operated water treatment facilities is based on MOE (1985a).

4. The same total as in Exhibit II-2.

ILLUSTRATIVE CALCULATIONS FOR THE APPLICATION OF REVENUE BASED SCHEMES TO ONTARIO

Exhibit IX-1, opposite, shows a breakdown for Ontario of water withdrawals by five major user groups for 1981. The industrial/manufacturing group is further broken down into 11 industry sub-groups. In the case of non-municipal users, the water withdrawals shown refer to self-supplied water only, i.e., direct takings from surface or groundwaters, excluding any water obtained from public sources of supply. Such public supplies are included in municipal withdrawals.

Exhibit IX-2, overleaf, is a summary table showing various estimates for the price elasticities of raw water intake. The elasticities are used for illustrative purposes to estimate the extent of water use reduction for a given change in the per unit price of water.

We have discussed in Chapter II the criteria by which pollutants might be selected for a charge scheme. For the purposes of this study we have selected BOD, TSS, TDS, Total Phosphorus, and Phenols. BOD, TSS and TDS are emitted in relatively large volumes by both industrial and municipal dischargers. They are not directly toxic at current levels and have standardized measurement techniques. On the other hand, Phosphorus and Phenols are emitted in rather small quantities, but were included in the loadings of the subject polluters in the Thunder Bay case study. Their inclusion in our calculations may indicate some difficulties to overcome when many pollutants are included in a charge scheme.

Exhibit IX-3, overleaf, shows, for two major groupings only, a breakdown of pollutant loadings for 1984.

Exhibit IX-4, overleaf, shows price elasticities for BOD and TSS loadings measured by weight. These were developed from data relating to increased costs to the brewing industry imposed by a sewer surcharge scheme. (Sims, 1979).

EXHIBIT IX-2

SUMMARY OF WATER INTAKE PRICE ELASTICITIES[1]
(Million Cubic Meters - MCM)

User Category	Estimate(s)	Source of Estimate(s)	Value Selected For This Study[2]
. Agriculture	-2.00 -1.50, -.46	Tate (1986) Muller (1985)	-1.32 (avg.)
. Minerals Extraction	-2.42	Renzetti (1986)	-2.42
. Industrial/Manufacturing:			
- Food and Beverages	-0.35 -0.40	Renzetti (1986) Tate (1986)	-.38 (avg.)
- Rubber, Plastics, Textiles	-1.54 -0.70	Renzetti (1986) Tate (1986)	-1.12 (avg.)
- Wood Products	-0.78 -1.40	Renzetti (1986) Tate (1986)	-1.09 (avg.)
- Paper and Allied Products	-0.39 -1.40	Renzetti (1986) Tate (1986)	-0.90 (avg.)
- Primary Metals	-0.01 -1.10	Renzetti (1986) Tate (1986)	-0.56 (avg.)
- Metal Fabricating	-0.23	Renzetti (1986)	-0.23
- Transportation Equipment	-1.21	Renzetti (1986)	-1.21
- Non-metallic Minerals	-0.25	Renzetti (1986)	-0.25
- Petroleum Industries	-1.79 -0.90	Renzetti (1986) Tate (1986)	-1.35 (avg.)
- Chemical and Chemical Products	-0.29 -0.70	Renzetti (1986) Tate (1986)	-0.50 (avg.)
. Thermoelectric Power Generation (Coolant)	-0.10	Muller (1985)	-0.10
. Municipal[3]	-0.93 -0.32, -0.57 -0.31 -0.82 -0.77	Grima (1972) Sewell & Roueche (1974) Macerollo & Ingram (1981) Sigurdson (1982) Tate (1986)	-0.66 (avg.)

Notes

1. The price elasticity of intake water measures the percentage decrease in the quantity of intake which results from a 1 percent increase in the price of intake.

2. It is difficult to make a choice between price elasticities obtained from different sources. Since we are using the elasticities for illustrative purposes, we have taken arithmetic averages of those shown.

3. For municipal water use, we have selected the annual price elasticity, instead of seasonal, or peak price elasticities.

EXHIBIT IX-3

TOTAL ONTARIO LOADINGS 1984
SELECTED POLUTANTS[1]
(Tonnes Per Year)

Source	BOD	TSS	TDS	T. Phos.	Phenols	Total
. Agriculture[1]	N/A	N/A	N/A	N/A	N/A	N/A
. Minerals Extraction/ Industrial/Manufacturing[2]	95,300	46,500	978,200	280	80	1,120,360
. Thermoelectric Power	N/A	N/A	N/A	N/A	N/A	N/A
. Municipal Waste Water Treatment[3]						
- Ministry Operated	7,400	7,000	N/A	450	N/A	14,850
- Municipally Operated	27,100	25,000	N/A	1,575	N/A	53,675
Municipal Subtotal	34,500	32,000	N/A	2,025	N/A	68,525
Provincial Totals	129,800	78,500	978,200	2,305	80	1,188,885

Notes

1. Agricultural pollution results from run-off rather than the discharges from specific point sources. Loadings data are not generally available.

2. Sources:

   - BOD, TSS, TDS from Figure 1, page 62 of MOE (1986).
   - Total Phosphorus from Table 22, page 62, ibid.
   - Phenols from Table 21, page 52, ibid.

   To break these totals down by specific industry groupings would require a special sort of the IMIS data.

3. Sources, MOE (1985a) and MOE (1985b).

EXHIBIT IX-4

POLLUTANT PRICE ELASTICITIES
BOD, TSS
(Brewing Industry)

Pollutant	Estimate	Source
BOD	- .57	Sims (1979)
TSS	- .45	Sims (1979)

EXHIBIT IX-5

REVENUE BASED WATER PRICING SCHEME
TARGET REVENUES OF $10 MILLION
CHARGE RATES AND SHARE OF CHARGES BY USER GROUP

(1981)

User Category	(1) Charge Rate Ignoring Price Elasticities (¢/10^3m^3)	(2) Charge Rate Taking Account of Price Elasticities (¢/10^3m^3)	(3) Share of $10 million Charges[1] (000)	(4) Percentage of Water Acquisition Costs Represented by Charges[3] (%)
Agriculture	47.1	N/A[2]	70	N/A
Minerals Extraction	47.1	51.3	54	3.1
Industrial/Manufacturing:				
. Food and Beverages	47.1	47.2	31	0.2[4]
. Rubber, Plastic, Textiles	47.1	47.6	42	0.9[4]
. Wood Industries	47.1	47.7	2	1.3
. Paper and Allied Products	47.1	49.9	280	5.8
. Primary Metals	47.1	48.3	520	4.3
. Metal Fabricating	47.1	47.2	2	0.1[4]
. Transportation Equip.	47.1	47.4	26	0.4[4]
. Non-Metallic Minerals	47.1	47.2	21	0.8
. Petroleum Industries	47.1	54.5	154	8.8
. Chemical and Chemical Prod.	47.1	48.8	876	6.8
. Other Industries	47.1	N/A	72	N/A
Sub-total			2,021	
Thermoelectric Power	47.1	54.5	7,030	116.1[5]
Municipal:				
. Ministry operated	47.1	47.2	119	0.2[4]
. Municipally operated	47.1	47.2	701	0.2[4]
Sub-total			819	
TOTAL			10,000	

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1. Found by multiplying the withdrawals in Exhibit IX-1 by the charge rate of 47.1¢/10^3m^3. These values were then treated as the "targets" when calculating the individual user group charge rates using elasticities in column 2.

2. We do not have water intake cost data for agriculture in order to calculate the charge rate, taking account of elasticities. The charge rate could be left as 47.1¢ or increased slightly. Because water withdrawals in this use are relatively small, the impact of differences in the charge rate on total revenue will be slight.

3. Determined as the ratio of column (3) to the acquisition costs in Exhibit IX-6.

4. These uses have a high proportion of publicly supplied water, reflected in the acquisition costs which include payments to municipalities. Thus, the percentage represented by charges appears low.

5. This percentage is extremely high because of the apparently relatively low acquisition costs recorded in the Water Use Survey.

Revenue Based Raw Water Pricing Scheme For Ontario

The Charge Rate And The Distribution Of Charges

For the purposes of illustration, we will assume that the annual target revenues are $10 million. Ignoring the price elasticity of intake water, the charge would be calculated by dividing this target by total annual withdrawals from Exhibit IX-1 in thousand cubic meters ($10 million/ 21,230,000), which results in a charge rate of $0.471 per thousand cubic meters, or $47.1¢/10^3m^3$ ($ 1981). The split of the target revenues between the user groups is shown in Exhibit IX-5, opposite. The year 1981 is used for this illustration since it is last year for which detailed withdrawal data are available.

Incentive Effect: Water Use Reduction

The imposition of a charge rate on water withdrawals should provide an incentive to reduce intake. The extent of reduced usage due to an increase in the price is measured by the price elasticity. We can use price elasticities to calculate the charge rates for each user groups required to generate the target revenues. The calculation algorithm is given in Appendix C. Based on the definition of price elasticity, the algorithm takes the current unit acquisition costs, volumes of intake, desired target revenue and price elasticity as inputs, and outputs the charge rate which will achieve the target.

In order to make these calculations, we need the current costs of water acquisition experienced by users. These have been surveyed in the 1981 Industrial Water Use Survey, Tate (1985a and 1985b). Tate (1985c, Page 15) states that the acquisition cost data do not include the capital costs of self-supplied water, but do include operating and maintenance costs. As well, payments made to municipalities for publicly supplied water are

EXHIBIT IX-6

WATER ACQUISITION COSTS BY USER CATEGORY[1]
1981
($000)

User Category	Acquisition Cost ($000)
. Agriculture	N/A
. Minerals Extraction	1,730
. Industrial/Manufacturing:	
- Food and Beverages	12,960
- Rubber, Plastics, Textiles	4,690
- Wood Industries	160
- Paper and Allied Products	4,820
- Primary Metals	11,980
- Metal Fabricating	2,040
- Transportation Equipment	6,160
- Non-metallic Minerals	2,630
- Petroleum Industries	1,760
- Chemicals	12,850
- Other Industries	N/A
Subtotal	60,050
. Thermoelectric Power	6,055
. Municipal[2]:	
- Ministry Operated	56,100
- Municipally Operated	330,830
Subtotal	386,930

Notes

1. **Sources:**
   - Industrial/Manufacturing: Tate and Scharf (1985b, Vol. I, Table 1.40)
   - Minerals and thermoelectric: Tate and Scharf (1985b, Vol. II, Tables 2.41 and 3.29)
2. The acquisition costs for the Municipal category are in fact the user fees for water collected by all municipalities in 1984, Ontario Ministry of Municipal Affairs (1984, page A7). The split by operator is the same as in Exhibit IX-1.

included. To be consistent for our purposes, we would want to consider only self-supplied user costs, i.e., the costs related to direct takings. However, these cannot be separated out from the Water Use Survey data as published. The reported acquisition costs, by user group are shown in Exhibit IX-6, opposite.

We have individual price elasticities for each user group identified in Exhibit IX-5. In order to apply the algorithm in appendix C, we require a target revenue for each group. It was therefore assumed in making these calculations that the target revenues for each user category are the same as the revenue share for each group which resulted from the application of the uniform rate of 47.1¢/$10^3 m^3$, as shown in Column 3 of Exhibit IX-5. The charge rates adjusted to take account of price elasticities are shown in Column 2 of the Exhibit IX-5.

We have also computed the percentage of current water acquisition costs (1981) represented by the charges, based on a target of $10 million, by user category. The results are shown in column 4 of Exhibit IX-5 and show that in most instances the additional costs resulting from the scheme are a relatively low proportion of water acquisition costs. However, these results are subject to qualifications regarding the data used in these illustrations:

- As noted on the Exhibit, some users involve a high degree of publicly supplied water. Thus acquisition costs derived from the Industrial Water Use Survey are overstated for our purposes of focussing on direct takings.

- On the other hand, capital costs for self-supplied or direct withdrawals are not included, leading to a potential under statement of acquisition costs, and overstatement of the percentage represented by charges.

EXHIBIT IX-7

INCENTIVE TO REDUCE WATER WITHDRAWALS REVENUE BASED CHARGE RATES

User Category	(1) 1981 Withdrawals[1] (MCM)	(2) Reductions Due to Charge Rate[2] (MCM)
. Agriculture	148	N/A
. Minerals Extraction	114	9.3 (8.2% reduction)
. Industrial/Manufacturing:		
- Food and Beverages	66	0.1
- Rubber, Plastics, Textiles	90	0.9
- Wood Industries	4	0.1
- Paper and Allied Products	595	33.0
- Primary Metals	1,103	27.5
- Metal Fabricating	4	negligible
- Transportation Equipment	56	0.3
- Non-metallic Minerals	44	0.1
- Petroleum Industries	326	44.5
- Chemical and Chemical Products	1,860	65.7
- Other Industries	153	N/A
Subtotal	4,301	172.2 (4.0% reduction)
. Thermoelectric Power Generation	14,925	2,001.2[3]
. Municipal:		
- Ministry Operated[3]	253	0.4
- Municipally Operated[3]	1,489	2.1
Subtotal	1,742	2.5 (0.1% reduction)
Total, all users	21,230	2,185.2

Notes

1. From Exhibit IX-1.

2. The charge rates used are those in column (2) of Exhibit IX-5.

3. On the basis of this calculation, there appears to be a significant reduction in withdrawals for thermoelectric power generation. This is a result of the charges being approximately the same size as the water acquisition costs. We have noted that for self-supplied users, these are likely deficient in the capital cost component, so that acquisition costs are significantly understated. This has the effect of significantly increasing the calculated "percentage price increase" represented by the charges which feeds into the calculation Algorithm of Appendix C. The application of the elasticity thus results in an apparent large percentage reduction in withdrawals.

- The water acquisition costs for thermal power generation (mostly Ontario Hydro) seem quite low, considering the volume of water withdrawn. Since almost no publicly supplied water is used for this purpose, these costs are understated because of the lack of capital cost data components.

In Exhibit IX-7, opposite, we show the decreases in water withdrawals, by user category, based on the adjusted charge rates shown in column 2 of Exhibit IX-5, which take into account available price elasticity estimates.

For the industrial/manufacturing users, the major reductions are, as expected, in the four major water using industries. Based on the charge rates, and elasticities we have used, and an overall target revenue of $10 million, we would expect a 4% reduction in industrial/manufacturing water use.

We note from Exhibit IX-7 that there is an apparent significant reduction in water use for thermoelectric power generation. As explained in Note 3 of the Exhibit, this high value is due to the insufficiency of the data. We have, in fact, no reason to expect percentage reductions that are significantly different from those in the other non-municipal user categories.

Administrative Costs

It was difficult to estimate some costs, particularly internal Ministry costs. These can be noted by the use of the word "assume". In these cases, the Ministry may more easily be able to ascertain the estimated costs.

For illustrative purposes, we assume that the approximately 6,200 permittees in the Permit to Take Water Program will face charges. The major incremental costs resulting from the implementation of the revenue based water pricing scheme are the following:

Set Up Costs

- o Metering Costs. Suppose that 50% of permittees require meters at an average cost of \$500 per meter.[2] Cost = .50 x 6200 x 500 = \$1.55 million.

- o Adjustments To Current MOE Municipal Billing System. Assume that changes to the current system of recordkeeping can be accomplished with 0.5 person years.

- o Other Set Up Costs, including the design of a meter auditing system. Assume these costs are 0.5 person years.

Ongoing Annual Costs

- o Meter Reading Costs. Regular readings should be conducted. Regional personnel should carry those readings out, perhaps twice per year. Since these readings may be combined with other work, we will assume 1/8 day per reading. Total annual days = 1/8 x 2 x 6200 = 1,550 days. At 238 days per person year, this requires about 6.5 person years.

- o Billing Account Personnel. Currently, the MOE municipal billing system handles about 250 accounts with 1.5

person years. Assume that to handle 6200 additional accounts might require another 5.0 person years. (This reflects the achievement of economies of scale.)

Using an average salary of $25,000 per person year[3], these costs may be summarized as follows:

Set Up

o	Meters:	$1,550,000	
o	Billing System:	25,000	(1.0 person year)
	TOTAL SETUP	$1,575,000	

Ongoing Annual Costs

o	Meter Audit:	$ 162,500	(6.5 person years)
o	Billing Personnel:	125,000	(5.0 person years)
	TOTAL ANNUAL	$ 287,500	(11.5 person years)

It should be noted that these estimates of administrative costs do not include items such as meter maintenance, and other internal Ministry costs such as office space, office equipment and computer hardware which might be necessitated by the implementation of this scheme. The Ministry may more easily be able to estimate these costs in a more detailed analysis.

Implications From The Calculations

The set up costs for metering are relatively high and the ongoing annual person year costs are estimated at 11.5. It is likely that, among the 6200 permittees, many "small" users account for a relatively small portion of the total annual provincial withdrawals. It should thus be possible, by increasing the threshold from 50,000 l/day and reducing the number of users being charged, to significantly decrease the costs, without decreasing revenues to the same extent. This line should be pursued in a revenue based pricing scheme.

In fact, a rough calculation of the average day water flows required to pay for a $500 water meter may assist in this decision:

- Assume straight line depreciation of the water meter over 15 years. Then the annual cost is $33.

- The average flows required, at 47.1¢/10^3m^3 to result in a $33 annual revenue are:

$$\frac{33 \times 1{,}000{,}000}{365 \times .471} = 192{,}000 \text{ l/day}$$

This indicates very roughly that the threshold should be about four times the 50,000 l/day threshold in the Permit to Take Water Program. However, we do not have reliable enough data (for example, the distribution of meter costs) to determine the threshold accurately in this study.

The calculation of the charge rates which take into account price elasticities require estimates of the elasticities. These may be gathered from the literature, but wide variations are found. It may be reasonable to make the uniform calculation first (47.1¢ as the charge rate in our example) and simply add on a percentage, say 5% or 10% to take account of the effect of price on quantity demanded. This would then preserve a uniform charge rate to be applied to all users.

For this study, a uniform illustrative rate may be determined by taking the total reduced withdrawals, calculated from Exhibit IX-7, and dividing into

EXHIBIT IX-8

DISTRIBUTION OF CHARGES FOR REVENUE BASED EFFLUENT CHARGE SCHEME

UNIFORM CHARGE RATE OF $8.41 PER TONNE
FIVE SELECTED POLLUTANTS
(Thousand Dollars, 1984)

Source	BOD	TSS	TDS	T. Phos.	Phenols	Total
Mineral Extraction/ Industrial/ Manufacturing	802	391	8,228	2	1	9,424
Municipal	290	269	-	17	-	576
	1,092	660	8,228	19	1	10,000

CHARGE RATES BASED ON WEIGHTS
BOD, TSS, TDS $6.68/tonne; Phosphorus $668/tonne; Phenols $6,680/tonne
(Thousand dollars, 1984)

Source	BOD	TSS	TDS	T. Phos.	Phenols	Total
Mineral Extraction/ Industrial/ Manufacturing	637	311	6,534	187	534	8,203
Municipal	230	214	-	1,353	-	1,797
	867	525	6,534	1,540	534	10,000

the $10 million target. This results in an average rate for all users of 52.5¢/ 10^3m^3 ($10 million/total of column 1 less total of column 2). Because of the Hydro data problem, this is likely an overestimate of the required rate.

Revenue Based Effluent Charge Scheme For Ontario

The Charge Rate And The Distribution Of Charges

Exhibit IX-2 shows the loadings for five selected pollutants for Ontario in 1984.

We shall assume, for illustrative purposes that the target revenues are $10 million. We must also have a way to determine the relative weights or importance per tonne of loadings for each pollutant. We have discussed this issue in Chapter VIII. Suppose that a tonne of each pollutant has a weight of unity. We could then base a charge on the aggregate loadings of the five pollutants. The charge rate is therefore $10 million/1,188,885 or $8.41 per tonne.

The charges would then be distributed as in Exhibit IX-8, opposite, top. A quick examination shows that about 82% of the charges result from TDS and insignificant amounts from Phosporus and Phenols.

We also illustrate the use of different weights per tonne of pollutant. We could suppose, for example, that each tonne of Phosporus is 100 times more "important", and that each tonne of Phenols is 1,000 times more "important" than a tonne of BOD, TSS or TDS. We would therefore calculate a revised charge rate, $x/tonne, for BOD, TSS and TDS by dividing the target revenue by the weighted sum of the loadings for all five pollutants. The charge rate for Phosphorus would be $10x/tonne, and for Phenols $1,000 x /tonne. The resulting charge rates, and distribution of charges is shown in Exhibit IX-8, bottom. As expected, the share of revenues for Phosporus and Phenols has increased significantly, while reducing the share of BOD, TSS and TDS.

Incentive Effect: Pollution Abatement

The imposition of a charge rate on these pollutants should provide an incentive to reduce emissions. It might be desired to adjust the charge rate, taking account of the price elasticity of emissions, again using the calculation algorithm shown in Appendix C.

Exhibit IX-4 provides only two price elasticities (BOD and TSS) from the brewing industry. They are of similar magnitude and average out at about -0.50. For illustration, we will use this value for all emissions for all mineral/industrial manufacturing uses.

We can re-calculate the charge rate by applying the algorithm of Appendix C for which we require estimates of total discharge treatment costs. These are available from the 1981 Water Use Survey in Tate and Scharf (1985a, Vol. I, Table 1.40 and 1985b, Vol. II, Table 2.41). The total discharge treatment cost for all manufacturing/industrial/mining users was reported as $78.14 million. Using the target of $9.424 million for these users (their share of charges under the uniform charge rate, shown on Exhibit IX-8, top) the adjusted charge rate is $9.03 per tonne. Thus, a charge rate of $9.03 per tonne for the five selected pollutants is required to generate the required revenues for industrial/manufacturing/mining, $9.42 million in revenues, taking account of the price elasticity of pollutant loadings. We could also use this rate for municipal emissions, if we assume that there would be similar price effects.

It must be stressed that the foregoing analysis is subject to severe limitations:

- We used an elasticity derived from the brewing industry for all non-municipal polluters.
- We have implicitly assumed that the discharge treatment costs relate, in effect, only to the five pollutants we have selected.

Administrative Costs

The Ministry may more easily be able to estimate certain internal costs, which we have indicated by the term "assume".

For illustrative purposes, the number of polluters subject to charges will include those in IMIS (150, say) and all municipalities (about 400). This results in about 550 potential accounts. The major incremental costs resulting from the implementation of the revenue based effluent charge scheme are the following:

Set Up Costs

- Adjustments to Current MOE Municipal Billing System. Assume that changes to the current system of record-keeping can be accomplished with 0.5 person years (less than the water pricing scheme).
- Other Set Up Costs, including the design of a mutually acceptable monitoring system. Assume this requires 1.0 person years.
- Composite Samplers. On the basis of the following discussion, one new composite sample is required for each of the six MOE regions[4].

  $1,000 x 6 = $6,000

Ongoing Annual Costs

- Monitoring and Laboratory Costs. As discussed in Chapter VIII, a reasonable approach is to institute an audit or verification program for data submitted by dischargers. It has been suggested that each of the 550 dischargers would require one composite sampling audit per year.[3] The costs would then include: personnel time to travel, set up, pick up the sampler estimated as one person day; one extra composite sampler per MOE region, (at $1,000 each); and laboratory tests for each sample at about $3 to $8 per chemical tested for.[5] For the 550 accounts, the incremental annual monitoring costs might be estimted as:
    - Personnel: 1 x 550 = 550 person days or 2.3 person years, say 2.5
    - Laboratory costs, for 5 tests per sample, at average cost of $5: 550 x 5 x 5 = $13,750.
- Billing Account Personnel. Assume that to handle another 500 accounts might require 1.0 person year.

Using an average salary of $25,000 per person year, these incremental costs may be summarized as follows:

Set Up

o Billing System:	$12,500	(0.5 person year)
o Other Set Up Costs:	25,000	(1.0 person year)
Subtotal	$37,500	(1.5 person years)

o	Composite Samplers	$ 6,000
	TOTAL SETUP	$43,500

Ongoing Annual Costs

o	Monitoring	$ 62,500	(2.5 person years)
o	Billing Personnel	25,000	(1.0 person year)
	Subtotal	$ 87,500	(3.5 person years)
o	Laboratory Costs	$ 13,750	
	TOTAL ANNUAL	$101,250	

It should be noted that these estimates of administrative costs do not include certain internal Ministry costs such as office space, office equipment and computer hardware which might be required. The Ministry may more easily be able to estimate these costs in a more detailed analysis.

Implications From The Calculations

- As we have noted, most charges result from TDS loadings and almost none from Phosporus and Phenols. This could be changed somewhat by giving more weight to the small loadings. However, they are so much smaller, that the weights would have to be quite large. The implications is, perhaps, that only large volume pollutants should be included in an effluent charge scheme.

- Although we attempted to make use of elasticities in this example, we would judge that the data at hand are not really sufficient. It would likely be acceptable to calculate the charge rate ignoring the effect of the elasticities and simply increase it by 5% or 10%.

EXHIBIT IX-9

THUNDER BAY CASE STUDY
ANNUAL DIRECT WATER WITHDRAWALS FOR 1984[1]
(Millions of Cubic Metres = MCM)

User	Source of Supply[2]	Estimated Annual Volume (MCM)[3]
• Water Treatment Facilities		
- Thunder Bay (Bare Point)	Bay	14.5
- Thunder Bay (Loch Lomond)	Lake	13.1
Subtotal		27.6
• Industrial/Manufacturing		
- Abitibi-Price (Ft. William)	Harbour	8.7
- Abitibi-Price (Thunder Bay)	Harbour	12.7
- Abitibi-Price (Prov. Papers)	Bay	18.2
- Great Lakes Forest Products	River	98.2
- Reichhold Chemicals	City	N/A
- Ogilvie Mills	City	N/A
Subtotals		137.8
• Thermolectric Power Generation		
- Ontario Hydro (Thunder Bay Generating Station)	Bay	11,442.8

Notes

1. There are other industrial water users who obtain water from the municipal system.

2. The sources of supply are:

   - HARBOUR: This means Thunder Bay Harbour, inside the breakwater
   - BAY: This means Thunder Bay, outside the breakwater
   - LAKE: This means Loch Lomond, about 1000 ft. in elevation above the City
   - RIVER: This means the Kaministiquia River, which reaches Thunder Bay via the Mission River
   - CITY: This means public water supplies.

3. These values are average day flows, multipled by 365.

Sources:

- Water Treatement data from UMIS, provided by MOE
- Industrial and Ontario Hydro: Effluent volumes taken from IMIS.

- Some of the incremental set up and ongoing costs may be reduced by eliminating from consideration for charges emitters of low volumes of discharges.

ILLUSTRATIVE CALCULATIONS FOR THE APPLICATION OF REVENUE BASED SCHEMES TO THE THUNDER BAY AREA

In this section we apply the water pricing and effluent charge rates developed in the previous sections to a case study comprising water users, and waste water dischargers in the Thunder Bay area.

Revenue Based Water Pricing Scheme

Exhibit IX-9, opposite, shows major direct water withdrawals and the sources of supply for the area. Two industrial water users are shown in this Exhibit with no direct withdrawals. They are included for the sake of completeness, since they appear in a similar Exhibit, following, which shows pollutant discharges.

It can be seen that all direct withdrawals are taken from Thunder Bay itself, except for some municipal water taken from a lake, and Great Lakes Forest Products which takes from the Kaministiquia River. The total withdrawals in the area are dominated by the Ontario Hydro thermoelectric power generation plant (98.6%). [In fact, based on these data, this plant accounts for over 50% of Ontario's total annual water withdrawals. This obviously needs checking: it is based on the IMIS statement that average day effluent is about 31 million cubic meters.]

Exhibit IX-10, overleaf, shows the distribution of revenues as a result of imposing the rate of 52.5¢/10^3m^3, incorporating the average impact of the appropriate price elasticities. It can be seen that Ontario Hydro would pay over $6 million, while all other users combined would pay well under $100 thousand.

EXHIBIT IX-10

THUNDER BAY CASE STUDY
DISTRIBUTION OF WATER CHARGES BY WATER USER
1981

User	Charge Revenues[1]
	($000)
• Water Treatment Facilities	
- Bare Point	7.6
- Loch Lomond	6.9
Subtotal	14.5
• Industrial/Manufacturing	
- Abitibi-Price (Ft. William)	4.6
- Abitibi-Price (Thunder Bay)	6.7
- Abitibi-Price (Prov. Pap.)	9.5
- Great Lakes Forest Products	51.5
- Reichhold Chemicals	N/A
- Ogilvie Mills	N/A
Subtotal	72.3
• Thermolectric Power	6,007.5

Notes

1. Calculated with a charge rate of $52.5¢/10^3m^3$, which incorporates average elasticity effects.

EXHIBIT IX-11

THUNDER BAY CASE STUDY
ANNUAL POLLUTANT LOADINGS FOR 1984[1]
(tonnes per year)

Discharger	Receiving Water		Loading[3] (tonnes/yr.)					Total
	Direct	Indirect[2]	BOD	TSS	TDS	T.Phos	Phenols	
Public Wastewater Treatment[5]								
· Thunder Bay	river	bay (1/2 km)	2,060	1,390	-	48	-	3,498
Industrial/Manufacturing								
· Abitibi-Price (Ft.Wm.)	bay	N/A	3,290	430	8,650	4	-	12,374
· Abitibi-Price (Th.Bay)	harbour	N/A	7,150	420	20,700	5	-	28,275
· Abitibi-Price (Prov.Pap.)	bay	N/A	1,370	640	4,820	2	-	6,832
· Great Lakes Forest Prod.	river	bay (7km)	18,000	4,450	94,200	75	-	116,825
· Reichhold Chemicals	river	bay (9km)	-	70	-	neglig.	neglig.	70
· Ogilvie Mills	river	bay (3km)	1,150	-	4,380	34	-	5,564
Thermoelectric Power								
· Ontario Hydro - Th. Bay Gen. Station[4]	bay	N/A	-	-		-	-	
TOTALS			33,120	7,400	132,750	168	-	173,438

NOTES:

1. Loadings are taken from UMIS for the wastewater plant, and from IMIS for Industrial/Manufacturing dischargers for 1984.

2. "Indirect" means that discharges ultimately are carried to this water body from the point of direct discharge.

3. Loadings are average day loads (kg/day) multiplied by 365 and coverted to tonnes (divided by 1000).

4. The "pollutant" discharged by Ontario Hydro is excess heat and temperature in comparison with the temperature of the receiving waters.

5. UMIS provides loadings only for BOD, TSS, T.Phos.

We would expect to obtain similar percentage decreases in water use as are shown on Exhibit IX-7 for the approprite user category, remembering the proviso regarding the calculations for Ontario Hydro.

Revenue Based Effluent Charge Scheme

Exhibit IX-11, opposite, shows the annual pollutant loadings for direct dischargers. We apply the average per tonne charge rate of $9.03 calculated above to all dischargers (including municipal). The breakdown of charge revenues by polluter is shown in column 2 in Exhibit IX-12, overleaf. It can be seen, for example, that:

- Great Lakes Forest Products would pay the majority of the charges (1055/1566 = 67%) and these are primarily due to TDS (see Exhibit IX-11).
- Reichhold Chemicals would pay very low charges (of about $600).

Interaction Of The Two Schemes

Exhibit IX-12 also includes the raw water charges shown in Exhibit IX-10, and provides the totals for both schemes. Two users would pay the majority of the water related charges in this area (Great Lakes Forest Products, and Ontario Hydro).

In the Thunder Bay area, except for the special case of Ontario Hydro, users would pay substantially more for effluents than intake water. This is reasonable where quality is a problem, rather than availability. Effluent charges for Great Lakes Forest Products would be about $1.1 million. The water charges for Great Lakes Forest Products would be about $52 thousand as well, and not insignificant.

EXHIBIT IX-12

THUNDER BAY CASE STUDY DISTRIBUTION OF CHARGES FROM REVENUE BASED WATER PRICING AND EFFLUENT CHARGE SCHEMES

User	(1) Charges For Water[1] ($000)	(2) Charges for Pollutant Loadings[2] ($000)	(3) Total Charges ($000)
. Municipality			
- Thunder Bay	14.5	31.6	46.1
. Industrial/Manufacturing			
- Abitibi-Price (Ft. William)	4.6	111.7	116.3
- Abitibi-Price (Thunder Bay)	6.7	255.3	262.0
- Abitibi-Price (Prov. Pap.)	9.5	61.7	71.2
- Great Lakes Forest Products	51.5	1,054.9	1,106.4
- Reichhold Chemicals	-	0.6	0.6
- Ogilvie Mills	-	50.2	50.2
Subtotals	72.3	1,545.4	1,606.7
. Thermolectric Power			
- Ontario Hydro	6,007.5	-	6,007.5
Totals	6,094.3	1,566.0	7,660.3

Notes

1. In $1981, based on 1984 withdrawals.
2. In $1981, based on 1984 effluents.

EXHIBIT IX-13

THUNDER BAY CASE STUDY
POLLUTION ABATEMENT STRATEGIES[1]

	(1) Current Emissions 1984 (tonnes)	(2) Expected Abatement Per Year (tonnes)	(3) Capital Costs ($ million)	(4) Annual Operating & Maintenance Costs ($ million)	(5) Total Annualized Capital Operating Operating & Maint. Costs[2] ($ million)	(6) (Average) Marginal Cost of Abatement[3] ($/tonne)
Abatement Strategies for BOD						
1. Abitibi-Priace (Th.Bay)	7,154	4,292	95.0	N/A	3.50	810
2. Great Lakes Forest Products	18,140	14,512	25.0	N/A	.92	60
3. Thunder Bay Municipal Sewage Treatment Plant	2,064	1,061	5.0	.13	.31	290
Abatement Strategies for TSS						
1. Abitibi-Price (Prov.Pap.)	642	193	4.0	N/A	.15	760
2. Reichhold Chemicals	72	22	1.0	N/A	.037	1,680
3. Ogilvie Mills	4,320	2,628	1.0	N/A	.037	14
4. Thunder Bay Municipal Sewage Treatment Plant	1,387	330	5.0	.13	.31	940

NOTES:

1. These strategies, and the associated capital and operating costs were provided by the Ministry of Environment.

2. For capital costs, we have used the 20-year capital recovery factor of .0736 as shown in Appendix B of Peat Marwick and Partners (1983, page B-3). This factor is used in the formula on page B-1 to estimate the Total Annualized Cost (Private) for capital operating and maintenance costs.

3. Found by dividing column 5 by column 2.

ILLUSTRATIVE CALCULATIONS FOR THE APPLICATION OF THE MARGINAL COST BASED EFFLUENT CHARGE SCHEME IN THE THUNDER BAY AREA

In order to determine the charge rate which will induce the desired abatement, it is necessary to collect data on the costs of abatement for the relevant range of technologies and strategies available for each polluter. With such data, we can construct the marginal abatement cost function. This specifies for each level of abatement, the cost of achieving the next unit of abatement. By examining the marginal cost functions for each identified polluter, the level of abatement for a given charge rate can be determined, based on the principle of equating the charge rate with marginal costs.

This methodology was carried out in Peat, Marwick and Partners (1983) for the group of sulphur dioxide producing industries in Ontario. Appendix B of that report details the calculations required to convert total capital and operating costs for a given abatement option into marginal costs. The simulation of firm-by-firm responses to selected effluent charge rates, using these data, is discussed in the main body of this report on page VI-7. We will follow this procedure, to the extent possible given data limitations, for the Thunder Bay case study.

For the purposes of the present study, data were gathered for some abatement strategies for the polluters identified for the case study. The relevant capital and operating costs, and the amount of abatement (reductions in emissions), are shown in Exhibit IX-13, opposite. These data have been provided by the Ministry of the Environment.

Also shown in this Exhibit in column 5 are the corresponding total annualized capital, operating and maintenance costs. These have been computed in accordance with the methodology in Appendix B in Peat, Marwick and

Partners (1983), as described in Note 1 in Exhibit IX-13. Column 6 lists the average annualized costs per tonne of abatement.

These are considered as the relevant marginal costs for all units of abatement up to the full level of abatement anticipated for each given strategy.

If, for example, Ogilvie Mills were acting to minimize its total costs, and if the cost estimates in Exhibit IX-13 were accurate, it should be willing to pay charges, rather than to abate, for any charge rate less than $14 per tonne of TSS. If the price were just above $14 per tonne, it would be less costly to undertake the abatement strategy.

Based on the data provided by the Ministry in Exhibit IX-13, it can be seen that:

For BOD:

- o No abatement in the Thunder Bay area would occur for a charge rate under $60/tonne of BOD.
- o Abitibi-Price is a very "high cost" abater, requiring a charge rate of $810 before it would be economic to undertake its abatement strategy.

For TSS:

- o No abatement in the Thunder Bay area would occur for a charge rate under $14/tonne of TSS. Above $14/tonne, 330 tonnes of TSS per year would be abated by Ogilvie Mills.
- o The rest of the abaters appear to be very "high cost" abaters, ranging from $760 to $1,380 per tonne.

Similarly high charge rates would be required to induce these companies to abate.

Data Qualifications and Implications

- These data are broad approximations, as is clear from the absence in most cases of operating and maintenance costs.

- We have been provided with only one abatement strategy per firm. Further study would be anticipated to reveal a range of strategies involving different levels of potential abatement and (average) marginal costs. In particular there may be lower cost strategies with smaller levels of abatement.

- The proper identification of the full range of abatement strategies available to the group of Thunder Bay polluters would enable a more satisfactory modelling of their behaviour in the face of given charge rates.

- In previous sections of this chapter, we developed a charge rate of about $9/tonne, for each of a group of five pollutants. The aggregate charges were expected to result in about $10 million revenues to the province.

  This rate seems relatively low in comparison to the high charge rates required to stimulate most of the strategies shown in Exhibit IX-13. Only one strategy is close, at $14/tonne. This likely reflects the lack of identification of other low cost strategies. However, we must also remember that the $9 charge rate was based on the total of the unweighted emissions of the five pollutants. TDS formed the majority of this total. To mitigate this fact, revenue targets may be set for each pollutant individually.

SUMMARY OF IMPLICATIONS

Revenue Based Water Pricing Schemes

- The charge rate is simple to calculate by dividing the target revenues by total withdrawals. Price elasticities may be incorporated to allow for the price incentive to decrease withdrawals. If good estimates of all the user category elasticities are not available, a factor of 5% or 10% should be applied to the initially calculated rate to keep it uniform for all users.

- With a uniform charge rate, Ontario Hydro would pay close to 70% of the total charges because withdrawals amount to this percentage. This percentage could be mitigated by targeting Hydro revenues at a lower proportion of the overall target, or assigning a lower charge rate on a "volume discount" basis.

- Analysis of set up and ongoing administrative costs indicates that the number of users who are billed should likely be substantially less than the 6,200 permit holders in the Permit to Take Water Program. The implication is that the average day threshold should likely be substantially greater than 50,000 l/day.

Revenue Based Effluent Charge Schemes

- Subject to the criteria discussed in Chapter II, the choice of pollutants for a charge scheme should likely include only those with relatively large loadings. In this case, "weighting" a tonne of each pollutant equally is reasonable. When pollutants with very low loadings are included on an equal weighting basis, the charges associated with them tend to become insignificant.

- The impacts of effluent price elasticities may be incorporated if data are available. Failing that, the basic uniform rate (Target revenues/total loadings) should be increased by a factor of 5% or 10% to reflect the incentive to reduce emissions in the face of an effluent charge.

- The Thunder Bay example indicates that there may be a number of sources in IMIS for which the billing and monitoring costs are not justified by the expected revenues. Analysis of both the IMIS and UMIS data bases should be undertaken to ascertain the threshold levels of the selected pollutants above which charges would be applied.

- Pollutants with relatively low loadings may be assigned individual revenue targets or, if included in groups of other pollutants with relatively high loadings, be assigned higher weights (which may reflect higher damages, or importance, per tonne).

- The selection of pollutants for a charge scheme would likely result in focusing on particular industries as the source of most revenues. For example, the pulp and paper industry is responsibile for large volumes of loadings of BOD and TSS.

Imposition Of Both Schemes On The Same User

- Some users may pay substantial charges resulting from each scheme. This may raise the perception of "double charging" for water use, especially in cases where water flow availability is not an issue.

Illustration of Marginal Cost Based Effluent Charge Scheme for Thunder Bay Base Case Study

- The main conclusion is that a thorough examination of the abatement strategies and costs available to polluters is required to simulate polluters' decision making behaviour when facing effluent charges. Depending on the particular situation being analyzed, various abatement cost functions might be required, such as:

    - individual polluters

    - aggregation of all sources of a specific pollutant

    - aggregation of all sources of a specific pollutant in a given watershed.

NOTES FOR CHAPTER IX

1. Personal communication with Mr. J. de Bakker, Ministry of the Environment, Northwest Region.

2. Personal communication. Mr. J. Toth, Ministry of the Environment, provided a range of current costs, excluding installation, from $60 to $1,640, depending on the volume of flow. We have no information regarding the distribution of size requirements. Thus the $500 price selected is arbitrary.

3. Mr. S. Pearce, Ministry of the Environment. Internal memo to Mr. J. Donnan, May 23, 1986.

4. Personal communication, Ms. S. Glover, Ministry of the Environment.

5. Personal communication, Mr. S. Villard, Ministry of the Environment.

X - SUMMARY AND CONCLUSIONS

In this chapter, we provide a brief summary and conclusions with regard to design factors and data requirements for water withdrawal pricing and effluent charges.

SUMMARY

Water Use In Ontario

In Chapter II, we described the various uses and services provided by natural waters in Ontario. The two major attributes of natural waters are their available flow and their capacity to assimilate pollutant loadings. We showed the extent of annual water withdrawals and the pollutant annual loadings to surface waters. We identified the nature of water use conflicts and identified current examples in Ontario. Except in localized instances, there are no current problems related to availability of flow. The major water use conflicts in Ontario relate to the impacts of pollution from waste discharges on other competing uses. Decreasing water quality is of concern, not only to present users, but to future users as well.

Economic Principles

In Chapter III, we described in detail the economic principles involved in the pricing of natural resources and, in particular, the pricing of raw water and effluents. The main principle is that an efficient allocation of society's resources will result if marginal cost pricing of all goods is adopted. Environmental attributes, such as available water flows and water quality are part of society's resources and have been used free of charge in Ontario.

Social costs (exernalities) can result from the use of water. For example, excessive withdrawals can reduce available flow below the minimum flows required for the life support of certain dependent ecosystems. Pollution damages can also result from the use of water for waste disposal. The fact that users do not pay for damages related to their water use can result in an inefficient allocation of society's resources. The user pay principle states that users of resources should pay the costs associated with their use. The application of the marginal cost pricing principle for water suggests the appropriate user price for water resources involves consideration of the social opportunity costs of its use, including:

- Marginal cost of goods and services directly required for its provision. (For water pricing, public funds devoted to water resource management should be included.)

- Resource depletion costs including impacts on other current and future uses.

- Damages to the environment.

With respect to the pricing and taxation of natural resources, the concept of economic rent as a return to a factor of production over that which would normally be required was described. Economic rent as a justification and basis for collecting resource royalties and taxes was discussed.

The possible policy objectives for natural resource pricing and taxation were set forth. The major objectives include revenue generation, the management of resource development and utilization, and income redistribution. These three objectives also apply to the pricing of raw water and effluents.

It was concluded that there are three main approaches to the determination of charge rates for water pricing and effluent charge schemes:

- Revenue based: The charge rate is essentially calculated by dividing desired target revenues by a measure of total annual water use (total water annual withdrawals, or total annual pollutant loading, respectively).

- Marginal Cost based: Depending on the availabilities of data on the costs of water-saving technologies and of abatement technologies, charge rates can be determined to reach desired levels of water use or effluent reduction, respectively. The resulting reductions will be achieved at minimum cost to society.

- Economic rent based: The charge rates reflect the existence of economic rents for some water users.

Criteria for the evaluation of charge schemes were described based on the economic principles set forth in Chapter III.

Natural Resource Pricing and Taxation in Ontario

In Chapter IV, natural resource pricing and taxation approaches in use in Ontario for timber, minerals, natural gas and water power rentals were described. Revenue generation is likely the dominant objective in resource pricing and taxation in Ontario. The various approaches to resource pricing and taxation in Ontario include:

- Severance tax or royalty based on the amount of resource removed.
- Severance tax or royalty based on a fixed percentage of sales revenues.
- Taxes on income or profits.
- Royalty based on volume of final product produced or sold.

The applicability of the various approaches to water and effluent pricing was evaluated. It was concluded that a scheme with a price or royalty per unit extracted is the most applicable for both raw water pricing and effluent charges.

Existing Water Pricing Schemes

In Chapter V, water pricing schemes in other jurisdictions were described and evaluated. Revenue generation is a focus of most schemes, along with simplicity of administration. In most cases, there seems little adherence to the economic principles we have discussed, such as social opportunity cost pricing, and allocative efficiency. For example, many schemes do not provide a (non-zero) marginal price incentive to conserve usage. In some cases where there is a non-zero marginal price, it appears that it is so low that water charges form an almost negligible fraction of total user costs of production so that the incentive effect is limited.

Existing Effluent Charge Schemes

In Chapter VI, effluent charge schemes in other jurisdictions were described and evaluated. Several examples were found in which the effluent charge rates provide sufficient incentives to reduce emissions. Most schemes have major revenue objectives with regard to the recovery of collective treatment costs or of water quality management costs. One important implementation difficulty concerning issues of allocative efficiency was pointed out with regard to the way in which municipalities, as direct dischargers, would pass on their charge liabilities to firms who discharge wastes indirectly into municipal sewer systems.

Possible Water Pricing Schemes for Ontario

In Chapter VII, we considered design factors for three possible raw water pricing schemes depending on the method of determination of the charge rate per unit of water withdrawn:

Revenue Based Water Pricing Scheme

- Charges are applied to all direct takings from surface and groundwaters in excess of 50,000 litres per day (essentially permittees under the Ontario Permit To Take Water Program, plus certain other large water takers who are exempt under this program).

- Metering is required.

- Collection of charges should be handled by the Capital Finance and Revenue Branch of the Ministry of the Environment.

- The uniform charge rate is determined by dividing the annual revenue target by the total annual withdrawals for users of over 50,000 litres per day.

- Data and information requirements include:
    - total annual water withdrawals of subject water users
    - desired revenue target.

Marginal Cost Based Water Pricing Scheme

- This scheme is applied to users in areas of scarcity of supply and is complementary to the uniform revenue based scheme. That is, all users pay the revenue based rate, except users in areas of scarcity who would pay the cost-based rate.

- The determination of the appropriate charge rate requires certain additional data and information, including:
    - the identification of areas of scarcity and a statement of water withdrawal objectives for these areas
    - estimates for individual water users on the costs of available water-saving and recirculating strategies.

Economic Rent Based Water Pricing Scheme

- This scheme is again a complement to the revenue based scheme.
- The charge rate is based on economic rents earned by users of relative "low cost" water in some watercourses, likely in areas of abundant flow and/or high quality.
- The determination of charge rates based on rents would require detailed studies of water usage and water costs by user/industry and watercourse.
- On balance, data problems and other data difficulties may make the determination of charge rates on the basis of economic rents impractical.

Possible Effluent Charge Schemes for Ontario

In Chapter VIII, we considered design factors for three possible effluent charge schemes, depending on the method of determination of the charge rate per unit of emissions:

Revenue-Based Effluent Charge Scheme

- Charges are applied to all loadings of selected pollutants for a group of polluters, such as those in IMIS and UMIS.

- A reasonable and mutually agreeable monitoring procedure is required. A reasonable approach is to complement loadings data as provided by polluters (to IMIS and UMIS) with a systematic audit or verification program.

- Collection of charges should be handled by the Capital Finance and Revenue Branch of the Ministry of the Environment.

- The uniform charge rate may be determined by dividing the annual revenue target by the total annual loadings of the selected pollutants.

- Data and information requirements include:

    - total annual pollutant loadings for the subject polluters

    - desired revenue target

    - determination of relative loading weights, if it is desired to calculate the charge rate by dividing the target revenues by the total of weighted loadings for each pollutant.

Marginal Cost-based Effluent Charge Scheme

- This scheme is applied in watercourses where water pollution is of major concern and is complementary to the uniform revenue based scheme. Polluters pay the uniform rate unless they are located in the polluted area.

- The charge rate determination requires additional data and information, including:
    - the identification of polluted watercourses of concern, and a statement of overall emissions objectives for the watercourses
    - data for individual polluters on available abatement strategies and their costs.

Economic Rent-Based Effluent Charge Scheme

- Essentially, the same comments may be made as in the case of the economic rent-based raw water pricing scheme.
- On balance, the difficulties in gathering the required data for the determination of the charge rate on the basis of economic rents may make this an impractical approach.

Illustration of Water Pricing and Effluent Charge Schemes

Chapter IX presented various illustrative calculations, based on available data, both for Ontario as a whole, and for a case study of water users and polluters in the Thunder Bay area. No data were available for illustration of the economic rent-based schemes. The main findings and conclusions are:

- For revenue based water pricing schemes:

  - Thermoelectric power generation (coolant water) would account for about 70% of the charges for Ontario as a whole.

  - Initial costs would be incurred for the installation of water meters.

  - On the basis of a comparison of meter and meter reading costs versus expected revenues, it would be justified to exempt smaller users and to apply the charges to a subset consisting of the larger water takers in the Permit to Take Water Program.

- For revenue based effluent charge schemes:

  - A minimum threshold value of loadings subject to charges should be adopted because revenues for lower loadings would not justify the billing and monitoring costs.

- For a marginal cost based effluent charge scheme in the Thunder Bay area:

  - Insufficient abatement cost data were available for a full illustration of this scheme.

OVERALL CONCLUSIONS

On the basis of the research, interviews and analysis undertaken for this study, we make the following overall conclusions:

- There is justification, in terms of the user pay principle and the principle of social opportunity cost pricing, for the pricing of both raw water and effluents in Ontario.

  However, the social opportunity costs associated with current withdrawal uses of raw water in Ontario appear to be relatively low overall. In localized instances only, there are examples of the imposition of social opportunity costs due to water withdrawals. Thus, it is difficult to justify more than very nominal charges for water withdrawals at present.

  The costs associated with raw water withdrawal uses are incurred by society in Ontario primarily in the form of public water management activities.

- It may be desirable to establish the principle of water pricing now, in anticipation of future growth in demand, and a potentially higher number of water withdrawal use conflicts.

- A revenue based water pricing scheme with a uniform charge rate may be appropriate to establish the principle of water pricing, and to recover public water management costs.

- In the case of the use of water for waste disposal, it is clear that social costs (damages) are occurring in Ontario, and that these will probably increase in the future.

- A revenue based effluent charge scheme may be designed to achieve specified target revenues from charges for the emissions of selected pollutants. The revenue targets might include estimated pollution damages, and public water quality management costs. The scheme should result in some abatement by polluters in response to charges.

- In watercourses where environmental damages are particularly severe, and it is desired to reach specified emissions objectives for certain pollutants, a marginal cost based charge scheme could be designed to achieve these objectives at the least cost to society. The charge rate is based on the costs of abatement technology for polluters. Implementation of the scheme would therefore require the initial investment of funds for the development of appropriate abatement cost data for polluters or groups of polluters on the affected watercourses.

- Effluent charge schemes would also require a reliable and mutually acceptable monitoring system. A reasonable approach is to accept loadings data as currently reported by polluters (in the Industrial and Municipal Monitoring Information Systems) and to implement a systematic audit or verification program.

- In order to facilitate the analysis of the feasibility and potential impacts of water and effluent charge schemes, further research is required in the areas of:

    - the price elasticities of demand for water services for different water user categories (e.g., agricultural use, major industrial groupings, and residential use)

- the capital and operating costs associated with water-saving and recirculating technologies and for pollution abatement technologies.

APPENDIX A

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APPENDIX A

BIBLIOGRAPHY

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APPENDIX B

CRITERIA FOR THE EVALUATION OF WATER AND WASTE WATER PRICING SCHEMES

APPENDIX B

CRITERIA FOR THE EVALUATION OF WATER AND WASTE WATER PRICING SCHEMES

ADMINISTRATIVE CRITERIA

These criteria deal with the administrative characteristics and requirements in implementing various environmental policies and include:

a. Incentive Effects

The application of this criterion would imply an assessment of the extent to which the desired behaviour of individuals or organizations is achieved by the policy. The strength of the incentive may be measured by comparing the costs of non-compliance with the costs of compliance. The possibility of inducing unanticipated effects should also be examined.

b. Information Requirements

Environmental policies have two sets of information requirements: the information required for set-up and the information required for day-to-day operation. For example, an effluent charge scheme would ideally require information on abatement costs in order to determine the appropriate charge level. Monitoring the discharges of various types of pollutants from each point source would then be required in order to calculate charge payments.

With regard to the information required for the set-up of a particular scheme, the availability of the required data must be determined and the cost of, or difficulty of collecting, feasible data elements described. The day-to-day information requirements for most schemes would consist of monitoring reports. In order to make such a comparison, the relative amount and degree of monitoring required for each policy option is estimated.

c. The Impact Of Revenue Generation

The magnitude of anticipated revenues may be an important factor in comparing alternative schemes.

Measurement of revenue generation is straightforward. For example, the anticipated revenues from an effluent charge scheme in a particular region can be calculated by multiplying the charge rate times the expected total emissions in that region over the agreed-to time period.

The impact of these charges on pollution sources can be assessed by comparing charge payments with various financial indicators of the firm's performance.

d. Costs To The Government

These costs are the administrative and litigation costs incurred by the environmental authority. While it is sometimes difficult to measure any differences in these costs across schemes, it is possible, a priori, to judge the administrative complexity and the likelihood of frequent litigation for various incentive schemes.

POLITICAL CRITERIA

These criteria are concerned with the political acceptability of various environmental policies. The criteria are:

a. Consistency With Current Legislation

An important test for any new policy would be its compatability with the existing legislative framework. Policies which require substantial alteration of current laws or departure from existing procedure are likely to be resisted. Policies can be compared by the extent to which existing legislation must be changed, new legislation or regulations must be introduced, and new regulatory procedures are required.

b. The Scope For Bargaining And Delay

Some policies create an inducement and provide an opportunity for firms to delay compliance. This occurs when the cost savings or benefits of delay exceed its costs.

c. Adaptability And Flexibility

In a dynamic world characterized by growth and inflation, it may be necessary to revise objectives, guidelines, penalties and other aspects of environmental policy in order to ensure continued achievement of the desired objectives. Frequent revisions in parameters may be undesirable because of the uncertainties created and because of the large capital commitments embodied in abatement programs. In addition, since legislative amendments may be made only infrequently, a policy or instrument that can adapt automatically to a changing world is desirable. Flexibility may also be required to meet differing regional requirements. Policies can be qualitatively compared with regard to their ability to adjust automatically and their need for periodic revisions.

d. Local Economic Impacts

This criterion concerns the short-term financial impacts, the effect on employment, the probability of plant closures, etc. resulting from alternate environmental policies. Local economic dislocations and disruptions caused by these policies can be determined qualitatively and compared among different policies.

SOCIAL BENEFIT CRITERIA

These criteria include:

a. Allocative Efficiency Or Cost-Effectiveness

Allocative efficiency refers to the achievement of maximum benefits through the utilization of society's resources. In some cases, it may only be possible to achieve a sub-optimal goal, that of cost-effectiveness.

A cost-effective scheme is one which achieves a stated goal (for example, the overall abatement of x kilograms of BOD per day) at the least cost to society. The comparison of environmental policies in terms of their cost-effectiveness requires knowledge of the appropriate environmental goals and of the various costs of achieving the goal by all relevant users. For water pollution control, the cost to society of abatement can be defined as the opportunity cost of resources used in the control of pollution. The "social" cost differs from the actual "private" costs imposed on the polluter. In the calculation of social cost, no consideration is given to transfer payments between the private and public sectors. These transfers include:

- transfers to the private sector due to income tax deductibility of operating and maintenance costs, and depreciation of capital costs of pollution control equipment or water-saving/recirculating equipment

- in the case, for example, of water or waste water pricing schemes, the charges for withdrawals, or residual emissions are transferred to the public sector

- other policy instruments, not the primary focus of this report, such as accelerated depreciation, sales tax rebates and grants all result in transfers to the private sector from the public sector.

b. Equity

Equity considerations deal with the extent to which various groups in society share the burden of charges imposed by the various schemes. These groups include:

- taxpayers
- management and shareholders of water using firms
- employees of water using firms
- consumers of the goods produced by the water using firms
- water users.

The above list refers to the incidence of charges and does not mention the victims of the externalities of resource use. Many people, for example, suffer knowingly or unknowingly from the effects of environmental pollution. Pollution abatement reduces these effects and may impact the cost structure of firms which generate pollutants. This can be regarded as more equitable since producers and consumers of water using or polluting goods and services bear more of the full social costs of these goods.

With respect to the distribution of the charges, there are many dimensions to equity, including:

o Incidence of costs over the main groups above.

o Incidence of charges within the user groups. Here, the treatment of firms under a particular policy instrument might be analyzed from several perspectives:

- total additional costs imposed by the instrument
- relative cost
- length of time in business
- control activities previously undertaken
- financial condition and the demand conditions for the firm's goods.

From the foregoing, it is clear that equity is not one criterion, but a set of criteria along various dimensions, sometimes conflicting. It is generally impossible to weight these in order to provide one unique measure of equity for each policy instrument.

c. Technological Innovation

Over the long-haul, one of the most important criteria on which to judge an environmental policy is the extent to which it spurs new abatement and process technologies which result in less costly pollution control or more efficient use of physical water supplies. Environmental policies may be judged on this dynamic basis, as well as the static bases inherent in the other criteria noted above.

APPENDIX C

CALCULATION ALGORITHM

APPENDIX C

ALGORITHM TO CALCULATE THE CHARGE RATE TO RAISE TARGET REVENUES, GIVEN THE PRICE ELASTICITY OF INTAKE WATER

Suppose at total costs to users of Po per unit, a quantity Qo is demanded. Suppose that an additional charge of r per unit (the "charge rate") is applied, making the new price $P_1 = P_0 + r$, and the quantity demanded decreases to Q_1. Suppose the price elasticity in this portion of the demand curve is e.

Then, we have, by definition:

$$e = \frac{Q_1 - Q_0}{P_1 - P_0} \cdot \frac{P_0}{Q_0}$$

$$\text{or} \quad e = \frac{Q_1 - Q_0}{r} \cdot \frac{P_0}{Q_0} \qquad (1)$$

Suppose that the target revenue at charge rate r is T. Then we also require that:

$$r \cdot Q_1 = T \qquad (2)$$

Substituting (2) into (1), it can be shown that the following equation results:

$$r^2 + \frac{P_0}{e} \cdot r - \frac{P_0 \cdot T}{Q_0 \cdot e} = 0 \qquad (3)$$

Using the quadratic formula, r may be solved for as:

$$r = - \frac{P_0}{2e} \left(1 \pm \sqrt{1 + \frac{4.e.T}{P_0 \cdot Q_0}} \right) \qquad (4)$$

(The negative root is selected).

The resulting decreases in withdrawals, $Q_1 - Q_0$, then found from restating (1):

$$Q_1 - Q_0 = e.r. \frac{Q_0}{P_0} \qquad (5)$$

APPENDIX D

CLASSIFICATION OF WATERBORNE POLLUTANTS

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CLASSIFICATION OF WATERBORNE POLLUTANTS

The following classification of pollutants is based on the Ontario Ministry of the Environment (1986, pp. 5-11) and Pearse et al (1985, Chapter 5):

- Physical pollutants include:
  - total suspended solids (TSS) such as bark, wood fibres, coke, coal, fly ash
  - excess heat, that is, discharged cooling water much warmer than the receiving waters.
- Oxygen Demand:
  - biochemical oxygen demand (BOD) of effluent from wastes from natural sources or human activities impacts the amount of dissolved oxygen in receiving waters. Discharged BOD can significantly reduce dissolved oxygen content
  - chemical oxygen demand (COD) relates to both organic and inorganic oxygen demand.
- Nutrients:
  - high concentrations of phosphorous and nitrogen can lead to excessive growth of algae and other aquatic plant systems. This is a natural process, but is accelerated by, for example, municipal effluent and agricultural runoff.

- Microorganisms:
  - waterborne bacteria and viruses can cause human illnesses, requiring strict supervision of public water supplies.
- Tainting Substances:
  - phenolics, as in effluent from a bleached kraft pulp mill are believed to cause off-flavour water and fish.
- Non-persistent Toxics:
  - oil and petrochemicals, ammonia-nitrogen, hydrogen sulfide
  - these toxics can pose a threat to natural and human eco-systems but are not persistent, i.e., they are susceptible to biological or chemical transformation.
- Persistent Toxics:
  - any toxic with a half-life (concentration) greater than 8 weeks is termed persistent
  - Polychlorinated Biphenyls (PCB's) are both persistent and bio-accumulative in living organisms
  - pesticides
  - heavy metals (arsenic, cadmium, chromium, copper, iron, lead, nickel)

- fluoride, pthalic acid esters

- total dissolved solids (TDS) include numerous varieties of dissolved minerals and materials. The most common salts are the chlorides, carbonates and silicates of sodium, potassium, calcium and magnesium. Natural waters contain TDS to a certain concentration. Difficulties can arise when the concentrations become excessive.

o Radiological:

- radioactive waste waters result, for example, from uranium mining activities.

o Atmospheric pollutants:

- airborne pollutants such as sulphur and nitrogen oxides may reach natural waters after falling from the atmosphere as acid rain or snow. These acids impact on the growth of fish and other aquatic systems.

o Miscellaneous pollutants:

- includes some chlorides, cobalt, cyanide.

APPENDIX E

LIST OF INDIVIDUALS INTERVIEWED

APPENDIX E
LIST OF INDIVIDUALS INTERVIEWED

ONTARIO GOVERNMENT

Mr. D. Vallery
Environmental Services Division
Ministry of the Environment
416-965-5115

Mr. P. Dennis
Policy and Planning
Water Resources Branch
Ministry of the Environment
416-965-6954

Mr. W. Suboch
Water and Wastewater Management Section
Water Resources Branch
416-965-6995

Ms. E. Dolinar
Water and Wastewater Management Section
Water Resources Branch
416-965-1655

Mr. J. de Bakker
Abatement Section
Northwestern Region
Ministry of the Environment
807-475-1205 (Thunder Bay)

Mr. S. Villard
Laboratory Services Branch
Ministry of the Environment
416-248-3001

Mr. J. Toth
Environmental Approvals Section
Environmental Approvals and Project Engineering Branch
Ministry of the Environment
416-965-1491

Mr. W. Small
Public Lands Section
Land Management Branch
Ministry of Natural Resources
416-965-2743

Mr. R. Milligan
Technical Services
Conservation Authorities and Water Management Branch
Ministry of Natural Resources
416-965-6281

Mr. S. Keen
Fuel Minerals Section
Land Management Branch
Ministry of Natural Resources
416-963-1883

Mr. J. Smith
Mining Lands Section
Land Management Branch
Ministry of Natural Resources
416-965-1380

Mr. A. Nausedas
Wood Allocation Section
Timber Sales Branch
Ministry of Natural Resources
416-965-2731

Dr. G. Anders
Metallic Minerals Section
Mineral Resources Branch
Ministry of Northern Affairs and Mines
416-965-1311

Mr. A. Frame
Electricity Section
Policy and Planning Division
Ministry of Energy
416-965-8073

GOVERNMENT OF CANADA

Mr. P.J. Reynolds
Socio Economic Division
Water Planning and Management Branch
Inland Waters Directorate
Environment Canada
613-997-2071 (Ottawa)

Mr. D. Tate
Socio Economic Division
Water Planning and Management Branch
Inland Waters Directorate
Environment Canada
613-997-1783 (Ottawa)

Mr. H. Foerstel
Socio Economic Division
Water Planning and Management Branch
Inland Waters Directorate
Environment Canada
613-997-2071

Mr. D. Bjonback
Planning Division
Water Planning and Management Branch
Western and Northern Region
Inland Waters Directorate
Environment Canada
306-780-5313 (Regina)

Mr. S. D'Aquino
Pacific and Yukon Region
Inland Waters Directorate
Environment Canada
604-666-3513 (Vancouver)

SASKATCHEWAN

Mr. L. Jones
Registrar
Saskatchewan Water Corporation
306-694-3975 (Moose Jaw)

Mr. R. Kellow
Planning Branch
Saskatchewan Water Corporation
306-694-3951 (Moose Jaw)

NOVA SCOTIA GOVERNMENT

Mr. J. Theakston
Water Management Section
Department of Environment
902-424-5300 (Halifax)

BRITISH COLUMBIA GOVERNMENT

Mr. D. Tanner
Water Management Branch
Ministry of Environment
604-387-1154 (Victoria)

OTHER ORGANIZATIONS

Ms. C. Coffin
Canadian Council of Resource and Environment Ministers
416-973-2218

Ms. S. Postel
Worldwatch Institute
California Office
415-326-0638 (San Francisco)